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ABSTRACT

This book contains edited versions of papers presented at a conference held at The Open University. The papers provide significant evidence of the depth of the problem of supply and retention of teachers of mathematics, and discusses the need for a structural review of the recruitment, selection, and training of teachers of mathematics. The conference began with a presentation of four papers: (1) "A Good Start--But Is It Enough?" (John Howson); (2) "Staffing the Mathematics Department and Teaching Mathematics?" (Gillian Thumpson); (3) "Learning Preferences of PGCE (Postgraduate Certificate in Education) Students: Implications for Recruitment of Mathematics Teachers" (Derek Woodrow); and (4) "Problem? What Problem?" (Tony Gardiner). The conference then broke into four groups focused on different but overlapping issues: School Mathematics, The Current Situation, Recruitment and Retention, and Teachers as Learners. In each group, further papers were presented and discussed. Papers include: (4) "Mathematics? No Thanks--Choosing and Then Rejecting Mathematics" (Leone Burton); (5) "Another Maths Schooling Crisis?" (Chris Ormell); (6) "Who Is Teaching Secondary Mathematics?" (Tom Roper); (7) "School Maths Teaching: The Thinking Person's Nightmare?" (Corinne Angier); (8) "Mathematics Teacher Shortages: Some Suggested Actions" (David Burghes); (9) "The Effects of Teacher Workloads and Other Fractions on Mathematics Teacher Recruitment and Retention" (Margaret Brown, Hamsa Venkatakrishman, and Sheila Macrae); (10) "Why Do People Decide to Train to Teach?" (Paul Andrews and Gill Hatch); (11) "Plug That Bath!" (Sue Sanders); (12) "Waving or Drowning? Teaching Adult Numeracy without a Strong Background in Mathematics" (Diana Coben); (13) "Teachers as Learners: Teacher Education in Mathematics and Science in a Professional Context" (Maj Asplund Carlsson and Brittmarie Somanni). (KHR)

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Key Stage 3 mathematics teachers: the current situation, initiatives and visions

Proceedings of a National Day Conference

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Contents

Introduction iii
Sue Johnston-Wilder
The Open University

Speakers' papers

A Good Start - But Is It Enough? 1
John Howson
Oxford Brookes University and Education Data Surveys

Staffing the Mathematics Department and Teaching Mathematics? 14
Gillian Thumpston
National Association of Mathematics Advisors (NAMA)

Learning Preferences of PGCE Students: Implications for Recruitment of Mathematics Teachers 22
Derek Woodrow
Manchester Metropolitan University – Institute of Education

Problem? What problem? 47
Tony Gardiner
School of Mathematics, University of Birmingham

Discussion group papers

A - School Mathematics

Mathematics? No Thanks – Choosing and then Rejecting Mathematics 58
Leone Burton
Visiting Professor of Mathematics Education, King's College London

Another Maths Schooling Crisis? 72
Chris Ormell
Philosophy for Education Renewal Group

B - The current situation

Who Is Teaching Secondary Mathematics? 81
Tom Roper
School of Education, University of Leeds

School Maths Teaching: the Thinking Person's Nightmare? 90
Corinne Angier
Sheffield Hallam University

Mathematics Teacher Shortages: Some Suggested Actions 99
David Burghes
Centre for Innovation in Mathematics Teaching, School of Education, Exeter University

C - Recruitment and retention

The Effects of Teacher Workloads and Other Factors on Mathematics Teacher Recruitment and Retention 113
Margaret Brown, Hamsa Venkatakrishnan and Sheila Macrae
Department of Education and Professional Studies, King's College London

Why Do People Decide to Train to Teach? 129
Paul Andrews and Gill Hatch
Faculty of Education, University of Cambridge and
Institute of Education, Manchester Metropolitan University

Plug That Bath! 141
Sue Sanders
University of Wales Swansea

D – Teachers as learners

Waving or Drowning? 146
Teaching Adult Numeracy Without a Strong Background in Mathematics
Diana Coben
School of Continuing Education, University of Nottingham

Teachers as Learners: 161
Teacher Education in Mathematics and Science in a Professional Context
Maj Asplund Carlsson and Brittmarie Samanni
Department of Education, Gothenburg University, Sweden

Plenary

Rebuilding the Profession of Mathematics Teaching: 169
Where are we and where can we go?
Celia Hoyles
Institute of Education, University of London
Chair of the Joint Mathematical Council of the UK

Introduction

The current problem with teacher recruitment and retention is a relatively new phenomenon, but the underlying shortage of mathematically qualified people has a longer history. In 1998, at least 20,000 secondary pupils in England and Wales lacked a qualified mathematics teacher; the situation now appears considerably worse. Shortages are masked through use of non-specialists with little or no mathematics background or qualifications. As the demand for mathematically qualified young people increases, the gap between supply and demand widens.

The supply of people willing to learn to teach mathematics may come from the pool of teachers of mathematics or other subjects who are currently not teaching, of older professionals who are ready to change careers or of teachers currently not working. It may also come from the pool of young people who do not elect to study A-level mathematics at sixteen. There needs to be greater knowledge of, and sensitivity to, the factors that encourage and discourage recruitment and retention of teachers of mathematics from each of these sources, in addition to the traditional routes.

In the light of this need, the Centre for Mathematics Education at the Open University hosted a day conference. This brought together people with a wide range of expertise and experience who identified critical issues and offered evidence to inform the debate. This book contains edited versions of papers presented on the day. Together the papers provide significant evidence of the depth of the problem of supply and retention of teachers of mathematics. They point to the need for a structural review of the recruitment, selection and training of teachers of mathematics.

The conference began with a presentation of four papers, each followed by questions. The conference then broke into groups focussed on different but overlapping issues. In each group, further papers were presented and discussed. Professor Celia Hoyles drew together some of the key issues in a closing plenary presentation and informed the conference about the planned role of the Advisory Committee for Mathematics Education.

Additionally, two background papers about the impact of technology on teacher supply and morale were made available to delegates. These are available on the website http://mcs.open.ac.uk/cme/conference/index.html

During the day, concern was expressed about the lack of public governmental data on teacher supply. It was noted that the last 4-yearly Department for Education and Skills Secondary Curriculum and Staffing Survey Bulletin was carried out in 1996.

Delegates reported that the day had been constructive. The papers in this book are offered as a basis for further action.

A Good Start - But Is It Enough?

John Howson

Oxford Brookes University & Education Data Surveys

Abstract

This paper considers the latest evidence on recruitment to maths PGCE courses and attempts to place the data in the context of the past twenty years. It also examines what evidence there is regarding the number of qualified maths teachers working in the maintained secondary schools system in England. Finally, it considers the degree of success of recent policies to increase the number of trained maths teachers and the government's evidence of the need for more teachers.

Schemes to encourage recruitment to teaching originated in the recruitment crises of the 1980s. Indeed, for most of the past fourteen years, the supply of qualified applicants has been insufficient to fill all the places on offer on maths ITT courses. In 1986, a financial incentive to teach was introduced in the form of a non means-tested, tax-free bursary that was additional to the student grant. Initially, this was only for those training as teachers of mathematics, physics or technology. (Bullock et al., 1989). Over the years the range of subjects covered by the bursary was extended as recruitment ebbed and flowed. For three years in the early 1990s there were no official recruitment problems. This led to a decision by the DfEE to abolish the bursary scheme in 1996. It was replaced in England, in 1997, by the Priority Subject Recruitment Initiative (PSRI), a scheme with a wider range of aims than a simple flat rate bursary to support students in subjects designated as shortages. The PSRI Scheme in England was in turn was replaced by the Shortage Subject Support Scheme (SSSS) in 1998 (TTA, 1997), although it continued in Wales.

In October 1998 the DfEE announced the introduction of 'golden hellos' for maths trainees on postgraduate programmes (DfEE, 1998). The most recent development was the announcement of training grants for all PGCE students entering training after September 2000 in England and Wales (DfEE, 2000, NAW, 2000). For math students this grant is in addition to the 'golden hello'.

Alongside the financial incentives introduced in the 1980s, the DES also established a unit to promote teaching as a career. This was known originally known as the Teaching as a Career Unit (TASC). On the establishment of the Teacher Training Agency (TTA) in 1995 the functions of the TASC unit were taken over by the TTA. In 1996 the TTA established its own teacher supply and recruitment team. The TTA team has worked alongside the DfEE in the operation of the recruitment incentive schemes in England ever since. Separate arrangements apply in Wales.

This article considers evidence on the early contribution that the most recent incentive schemes introduced since the autumn of 1998 may have played in recruitment to maths ITT post graduate courses recruited through the Graduate Teacher Training Registry (GTTR). The Registry handles most applications for secondary PGCE courses in England and Wales with the exception of some school centred courses (SCITTs). GTTR does not handle applications to the Open University PGCE course.

Table 1: Applications to GTTR for secondary PGCE courses in mathematics

Year	Applications	Notes
1994	2,372	
1995	2,176	
1995	1,873	
1996	1,579	
1997	1,288	
1998	1,671	Golden Hellos introduced in autumn 1998 for 1999 Entry
1999	1,776	Training Grants introduced March 2000 for 2000 Entry
2000	2,031	to 23rd September 2001

(Source: GTTR, 2000)

As the figures for recruitment to mathematics courses, as opposed to simply applications, show (Table 2), recruitment fell away during the mid 1980s, recovered, and then fall away slightly to reach a low in 1990-91. The next three years witnessed a significant turnaround as recruitment rose by a third in two years during the period that the economy was in recession. By 1995-96 recruitment had started to fall away sharply to reach a low point in 1998-99. In November 1998 the introduction of 'golden hellos' had a positive effect and recruitment picked up for the first time in six years. The following recruitment round did not produce any further significant increase in recruitment over 1999-2000. This was mainly due to a collapse in the undergraduate route, where students were faced with the double 'whammy' of both being liable for tuition fees and exclusion from access to the Training Grant.Evidence from the 2000-01 recruitment round is that applications for centrally recruited PGCE

Table Two: Recruitment to all ITT maths courses

Courses starting	Target	Recruited	Shortfall	% short fall
1983-84	1164	1122	42	4%
1984-85	1184	993	191	16%
1985-86	1201	858	343	29%
1986-87	1275	901	374	29%
1987-88	1383	1194	189	14%
1988-89	1572	1143	429	27%
1989-90	1533	1138	395	26%
1990-91	1727	1091	636	37%
1991-92	1215	1550	-335	(-24%)*
1992-93	1715	1874	-159	(-9%)*
1993-94	1935	2010	- 75	(-4%)*
1994-95	2155	2050	105	5%
1995-96	2380	1890	490	21%
1996-97	2700	1770	930	34%
1997-98	2370	1540	830	35%
1998-99	2270	1190	1080	48%
1999-00[a]	1680	1390	290	17%
2000-01	1850	1380	470	25%

[a] Excludes the 500 places removed for employment based route scheme; * Surplus

Source: School Teachers Review Body Annual Reports 1993-2001 courses has risen sharply to reach its highest level for 6 years. No details about undergraduate numbers is yet available.

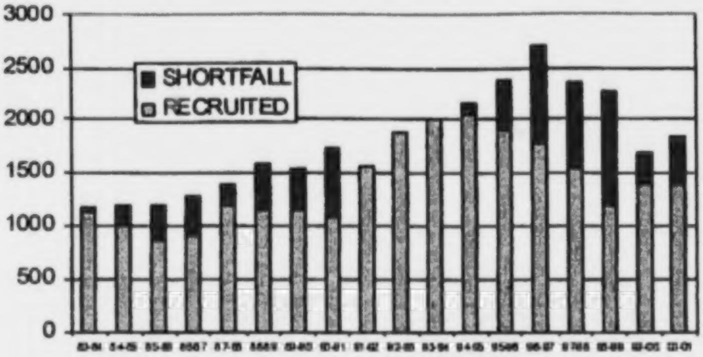
The overall shortfall during period 1983-84 to 2000-01 left just over 6,000 maths places unfilled.

Table 3: Recruitment to undergraduate ITT courses in maths

1992/93	452
1993/94	283
1994/95	425
1995/96	373
1996/97	296
1997/98	na
1998/99	192
1999/2000	193 plus 23 Autumn Term GTP
2000/01	147 plus 37 Autumn Term GTP

Using the maths figures it would seem that the introduction of the bursary in 1986 had a short lived positive effect on recruitment. Applications rose in 1986-87 and 1987-88 before starting their decline to the low point in 1990-91. By that time two changes had taken place that affected the potential supply of new recruits. Firstly, the economy had entered recession and secondly, higher education had begun to expand. The effect of these two factors during the early 1990s allowed recruitment to maths courses to pick up quickly reaching a high in 1993-94. It was when these figures were released that the DfEE began to consider the future of the bursary scheme. The prevailing view, possibly supported by the Treasury, was that the bursary was being paid unnecessarily to many students who would have chosen to become a teacher even if there had been no financial support. The cost of attracting each additional new teacher was, therefore, thought to be very great in cash terms. (Charts 1 to 3)

CHART 1: RECRUITMENT TO MATHS ITT COURSES



SOURCES: STRB & IAC *EDUCATION DATA SURVEYS*

CHART 2: RECRUITMENT TO MATHS ITT COURSES

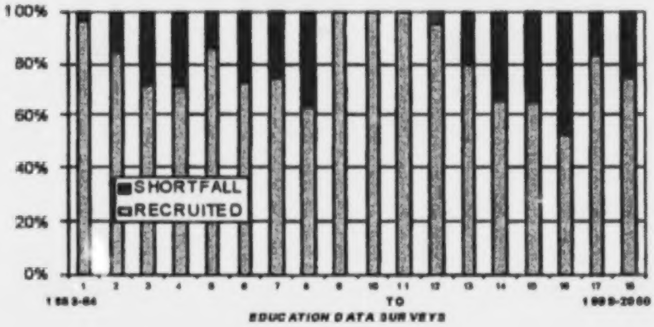
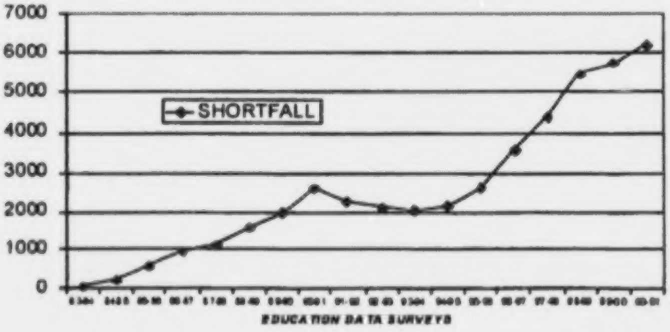


CHART 3: CUMULATIVE SHORTFALL

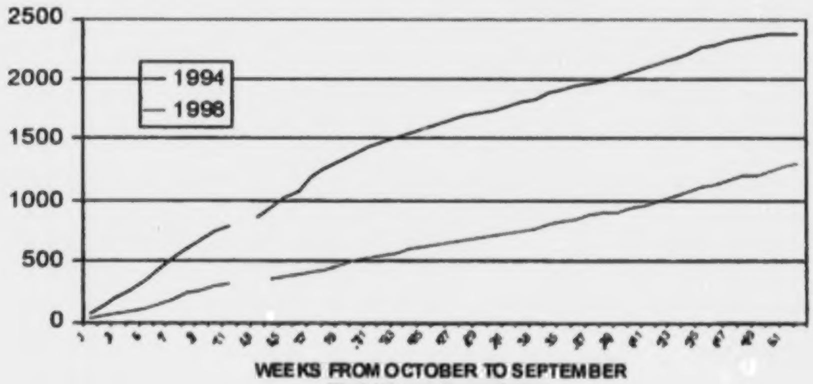


The decision was taken to replace the bursary with a new scheme, the Priority Subject Recruitment Initiative (PSRI), to be run by the newly formed Teacher Training Agency (TTA). The basis for this new initiative was that providers would bid for funding. This funding could be used both for recruitment activities and student support that could include a bursary element, but was not to be confined to just a bursary. The allocation of funds for marketing purposes directly to ITT providers marked a new departure.

The PSRI scheme was launched just as recruitment started to decline rapidly. Within two years the original scheme was repackaged by the Teacher Training Agency as the Shortage Subject Support Scheme (SSSS). (TTA, 1997)

The background of an improving economy and constant criticism of schools meant that these 'difficult to market and problematic to administer schemes' seemed to be able to do little to stem the decline in recruitment. In 1996, there was the first of the two House of Commons Select Committee Reports on teacher supply (House of Commons, 1997). This was followed within a year by a second report from the same Committee (House of Commons, 1998). Commentators were already warning about the effects of a decline in the number of applications against a rise in the training targets needed to accommodate both a rising tide of early retirements and the under-

CHART 4: APPLICATIONS FOR PGCE MATHS COURSES
WEEK BY WEEK



EDUCATION DATA SURVEYS

recruitment of previous years. (Robinson & Smithers, 1998). (House of Commons, 1998).

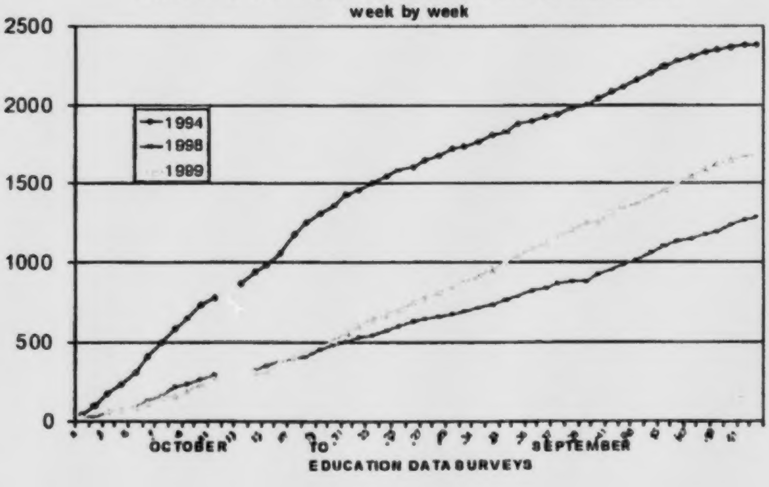
The next step came in November 1998 with the announcement of the 'golden hellos' scheme by Estelle Morris on behalf of the DfEE (DfEE, 1998). At that time, in November 1998, recruitment for entry to the 1999 courses was already below the same period in 1997, for entry to the 1998 courses, (Chart 4)

Allowing for time to publicise the scheme and for the Christmas holiday period, it is not surprising that it was not until January 1999 that recruitment began to pick up. The improvement for the rest of the year was significant.

The end result was an increase in recruitment of 400 extra students. The percentage of unfilled places declined even more dramatically as the DfEE stripped out 500 training places from the higher education target to trial a new employment based initiative.

Despite the early failure of that initiative, those training places have yet to be fully added back into the higher education ITT training target. (Chart 5)

CHART 6: APPLICATIONS FOR MATHS COURSES
week by week



Training grants

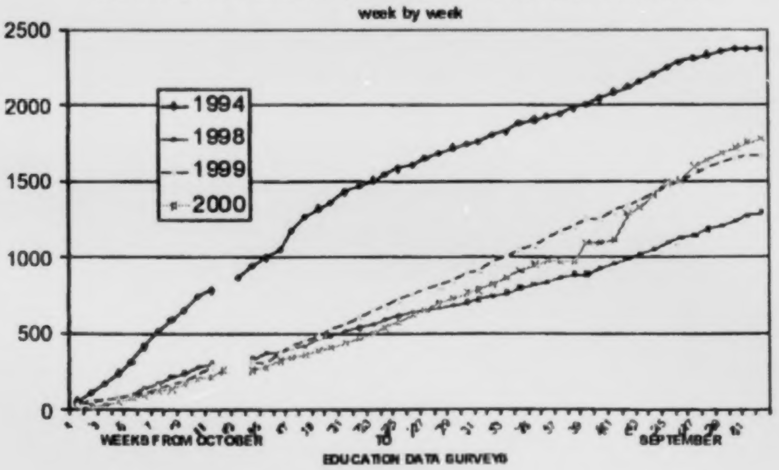
In late March 2000 the DfEE unexpectedly announced a new initiative offering a training grant of £6,000 to all students that entered postgraduate courses from September 2000. Maths trainees could, therefore, receive up to £10,000 over two years. (DfEE, 2000), (NAW, 2000)

When these measures were announced, recruitment, even in the 'golden hellos' subjects, such as maths had been weak since the start of the recruitment cycle. ITT managers attending the UCET Management Forum members had been warned in as early as November 1999 that it was likely to prove a difficult recruitment cycle (Howson, 1999).

An analysis of applications to GTTR for March 2000 compared with the same date in 1999 revealed that much of the reduction in applications in the early part of the recruitment cycle was due to a collapse in applications from people over 25. Indeed, applications from new graduates were holding up very well, even before the March announcement. (See Table 4.)

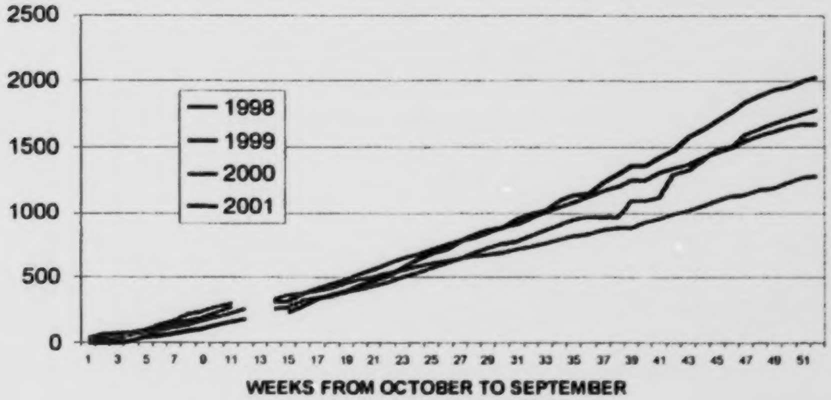
Between the end of March 2000 and September 2000 there was some additional growth in applications, but it was only in the order of 5% for maths PGCE courses. (Barnard, 2000) (Chart 6)

CHART 6: APPLICATIONS FOR PGCE MATHS COURSES



The recruitment cycle for the 2001 courses again started slowly, and did not pick up momentum until the early spring of 2001. Indeed, it was not until two-thirds of the way through the recruitment cycle that applications first exceeded those for the 1999 (post golden hellos) cycle. However, from May to September 2001 there was a surge in applications that took total numbers of applications to some 14% above the level of September 2000. (Chart 7)

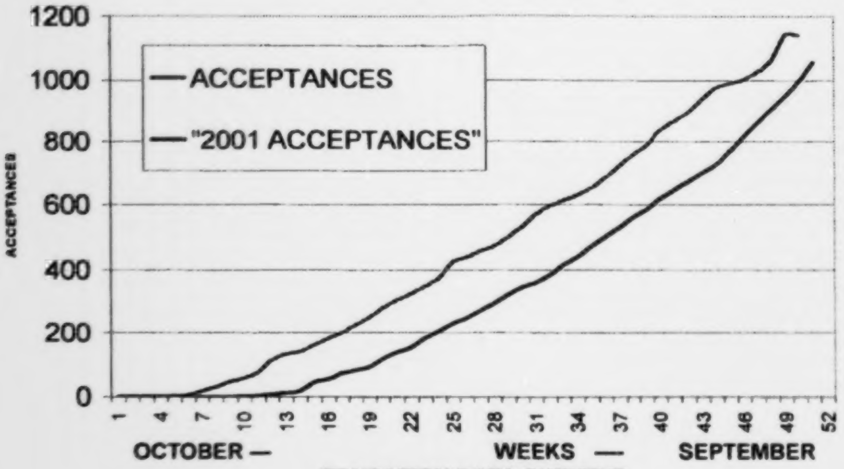
CHART 7: APPLICATIONS FOR PGCE COURSES WEEK BY WEEK



EDUCATION DATA SURVEYS

Applications are one thing, acceptances of those who apply is another matter. Not enough is known of the decision making process adopted by admission tutors, but it may be that when applications are thought to be falling there is an incentive to recruit as many students as possible. However, when incentives are introduced, such as the 'golden hellos' and training grants, tutors may expect an increase in applications and become more careful about offering places, as they expect more applicants to be able to select from. The evidence certainly suggests that acceptances for places on the 2001 courses have lagged behind those for the 1999 courses despite the increase in applications. (Chart 8)

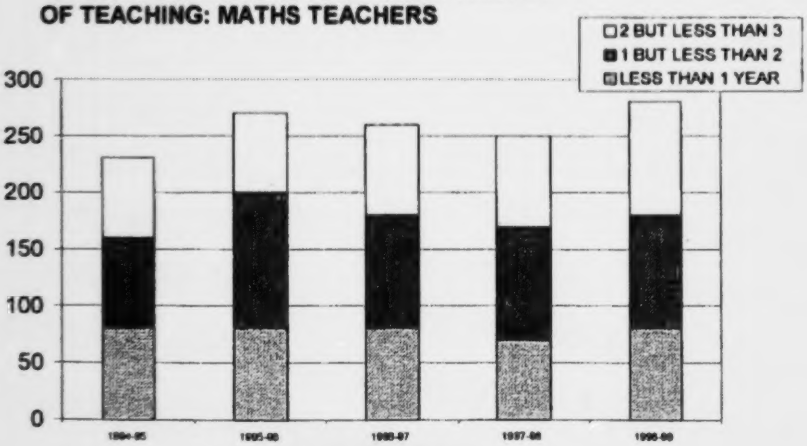
CHART 8: MATHS GTTR ACCEPTANCES 1999 & 2001
WEEK BY WEEK



EDUCATION DATA SURVEYS

As yet, it is too early to know whether applicants recruited onto courses following the introduction of the 'golden hellos' and the training grants are more likely to remain in teaching than their predecessors. Generally, around 250 teachers in their first three years of maths teaching leave the profession each year, according to figures from the DFEE (Hansard, 2001). The number of those leaving seemed to be increasing in the late 1990s, the last years that figures are available for at present. (Chart 9)

CHART 9: LEAVERS IN FIRST THREE YEARS OF TEACHING: MATHS TEACHERS



EDUCATION DATA SURVEYS

Issues for discussion

How successful have the training grants been? On the one hand, they were introduced part way through the recruitment cycle when many final year students had already found jobs or were committed to postgraduate study. This may have reduced the number of possible applicants in their first year of operation. An analysis of the age of applicants to GTTR reveals that there was a rise in the relative percentage of older applicants in the total number of applicants for secondary PGCEs between the position in March before the training grants were announced and October 2000, as courses commenced. This suggests that the Grants may not have been as successful at attracting new young graduates as might have been predicted. (See Table 4). A similar analysis of this recruitment round has yet to be undertaken.

Table 4 – Age of applicants to GTTR for secondary PGCE course starting in autumn 2000 as at March and October 2000

	Male March	Male October	Female March	Female October	Change Male	Change Female
20-24	51%	39%	61%	52%	-12%	-9%
25-30	26%	27%	20%	24%	+ 1%	+4%
31-40	16%	22%	13%	16%	+ 6%	+3%
40+	8%	13%	6%	8%	+ 5%	+2%

On the other hand, as a simple national scheme the Training Grants, like the original bursary scheme, are easy to advertise compared to relatively complicated PSRI and SSSS initiatives that differed from provider to provider in their exact composition. However, even the latest schemes still offer nothing to encourage job changers who still enter training without the certainty of a teaching post on completion of their courses.

Conclusion

Have the grants been more successful in a full recruitment cycle? The evidence from their first full year would seem to be positive, at least as far as applications are concerned. However, with the transfer of the cost of higher education from the State to the individual, any training course will have to compete both with a student's desire to minimise their existing levels of debt and their views of teaching as a career. New initiatives also draw in those who might have delayed entering teaching. This can produce an inflated first year recruitment figure. The recruitment round for courses starting in 2001 has been further complicated by the introduction of the Fast Track Initiative (DfEE, 1999) by the government, although initial numbers applying have been relatively low.

What is certain is, that unless teaching remains competitive with other careers in terms of remuneration, working conditions and incentives, the accumulated deficit in the number of teachers trained in recent years will not be reduced. As many teachers will reach retirement age during the next ten years, society cannot afford a prolonged period of under recruitment to ITT courses. Without sufficient able and well-qualified teachers it may become more difficult to meet the government's improvement targets for maths.

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Staffing the Mathematics Department and Teaching Mathematics?

Gillian Thumpston

National Association of Mathematics Advisors (NAMA)

Abstract

This paper considers a range of concerns related to the shortage of mathematics teachers including: the quality of mathematics teaching, larger class or set sizes, reduced lesson time, reduction in courses offered particularly post-16 and the difficulty implementing the mathematics strand of the Key Stage 3 Strategy. The views of a small sample of heads of mathematics on the staffing of their departments and its impact on the teaching and learning of mathematics are presented. The issues raised by these heads of mathematics together with contributions from the National Association of Mathematics Advisers (NAMA) members in other parts of the country, provide a preliminary focus for discussion of the impact and implications of the mathematics teacher shortage.

Background

Among the questions asked and issues raised at the British Congress of Mathematics Education (BCME) in July 2001 were concerns about the supply of mathematics teachers. The shortage of mathematics teachers was seen as leading to poor teaching which discouraged pupils from studying mathematics beyond the compulsory phase, which in turn exacerbated the shortage of teachers. It was also noted that the TTA Skills Tests were discouraging people from taking up teaching.

'Heads forced to hire bad teachers' (TES 2001) was just one of the headlines that greeted teachers as they started the new academic year. New members of staff were faced with meeting students knowing that they had been denounced as teachers that head teachers would 'rather not touch with a barge pole' (TES 2001). Why would anyone want to be a mathematics teacher at the moment?

The shortage of mathematics teachers and its implications for mathematics teaching and learning, is a matter that greatly concerns The National Association of Mathematics Advisers (NAMA). The number of students wishing to train to teach mathematics has always been small in comparison to many other subject areas. There have been many contributing factors including the public image of mathematics. The number of adults who will freely admit that they cannot do mathematics is still greater than the number who will admit to being unable to read or write.

In the recent past some schools have had more difficulty than others in recruiting mathematics staff. Now all schools are having difficulty recruiting at all levels. Incentive points, retention points and 'golden hellos' have been in vain. Schools have to advertise three or more times in an attempt to secure suitable candidates for interview. Data collected in a small study by NAMA suggests that many mathematics departments are relying on teachers from overseas to fill main scale vacancies in their departments. In some instances the head and second in department posts are filled temporarily by senior teachers with other subject specialisms.

The study

The purpose of the NAMA study was to investigate the views of heads of mathematics departments on the shortage of mathematics teachers and on the impact this was having upon the management of their departments and upon the teaching and learning within the school. From this study, NAMA hoped to identify strategies that would contribute to retaining existing mathematics teachers and improving recruitment. A group of NAMA members drew up a short list of questions that formed the basis for the interviews with heads of mathematics departments. In addition, I contacted other NAMA members across the country and asked them for information concerning mathematics teacher shortage, recruitment and retention. I had responses from mathematics inspectors, advisers and consultants from seven other authorities. My mathematics consultant and I also interviewed fifteen heads of department. The data was collected by telephone conversation or during a school visit during the first three weeks of the current academic year.

Findings

1. Deployment of staff. When asked about the staffing in their department, the initial response of all the heads of mathematics in the study was to say they were fully staffed. However during the course of the interview it became clear that 'fully staffed' was interpreted in different ways. All but one department had teachers to cover the mathematics timetable; not one department had a full complement of mathematics specialists. With one exception all of the departments in the study expect to have vacancies either from January 2002 or at the end of the academic year (when contracts finish or teachers retire).

The majority of schools in the study are experiencing the uncertainty of staffing that comes with staff on short-term contracts and/or relying on the goodwill of ex-members of the department. Several departments have persuaded retired members of the department to return to cover classes until a permanent appointment can be made. Where non-specialist teachers were employed they teach Years 7 to 9 and often the lower sets. This raises questions concerning equal access to mathematics for all ability groups, the level of expectation and the impact on the motivation of both pupils and teachers. Less experienced teachers were expected to teach across Key Stages 3 and 4 and across the ability groups but not A or AS level. One department employs a teaching assistant to teach lower set Year 7 pupils.

2. Class sizes and lesson lengths. Heads of mathematics are trying hard to ensure that mathematics continues to be taught. In order to do this they have increased the size of some classes and sets. The average class size was 30 but with some schools the upper sets in Year 9 and at Key Stage 4 had fewer pupils. In other departments the lower sets had fewer pupils and in others both upper and lower sets had reduced numbers, leading to large middle sets. One large school has reduced the number of sets in KS3 from 12 to 10, which gives larger numbers of pupils in each class but enables then to be taught by specialists. The head of department is not looking forward to larger classes but feels it will be more positive than having to cover for classes without a teacher or dealing with the aftermath of unsatisfactory supply cover.

In some cases the amount of lesson time has been reduced. Where schools are providing the recommended teaching time of three hours a week at KS3, less experienced, non-specialist teachers and sometimes, teaching assistants are employed. Some schools have adopted a 'continental day', which has led to reduced time for all subjects and not only mathematics. As a result of the implementation of the mathematics strand of the KS3 strategy several schools have had to adjust their timetable to ensure that pupils in KS3 receive the recommended mathematics teaching time.

3. Post-16 provision. Those teachers who are willing and able to teach at the higher levels are meeting increased demands upon their time. They teach additional classes that can no longer be accommodated within the timetable outside the school day. For example, departments have found that the number of students taking Further Mathematics has reduced due to the broadening of study in the sixth form. In order to allow students to take Further Mathematics, such departments are teaching this course before or after school. Many departments are also running GCSE 'resit' classes after school. The new style AS courses have proved difficult for even the most capable students and appear to have contributed to a decrease in the numbers of students wanting to continue with mathematics. The smaller number of teachers willing to continue teaching at this level was also having an effect on the numbers of students continuing.

4. Staff development. In most schools, heads of department make good use of department meetings by reducing time spent on routine administration with a written weekly update sent to each teacher. This allows time to be spent on developing mathematics teaching and learning, for example, incorporating ICT into schemes of work, carrying out audits, scrutiny of pupils' work.

The majority of departments had at least two members of staff with a main teaching responsibility in other departments. As most schools have all department meetings at the same time, such teachers often miss mathematics department meetings as they have to attend the meeting for their department. When such teachers were unable to attend then staff developments were not possible. Also it was often the teachers who would most benefit from these meetings, for example the less experienced or non-specialists, who were unable to attend. This problem is compounded in some departments where the less-experienced or non-specialist teachers are working with Year 7 students. These teachers have not had the opportunity to receive any training concerning the implementation of the mathematics strand of the Key Stage 3 (KS3) Strategy or the implications of the National Numeracy Strategy (NNS) for the attainment of pupils transferring from primary schools.

This situation is exacerbated by the implementation of the Key Stage 3 Strategy. The schools in my authority are committed to raising standards and went to enormous trouble to release staff for both the English and mathematics initial training. Teachers want to continue with the programme of training. For many mathematics teachers this is their first opportunity since college to develop their teaching and learning of mathematics. Head teachers would like the courses to run after school or at weekends but recognise the added pressure on staff. Training at weekends and in the evenings also has implications for equality of opportunity. Other teachers cannot be released to attend training during the school day as supply teachers are increasingly difficult to find..

5. Teaching assistants. Most departments have learning support assistants (LSAs) for pupils with special educational needs in the mathematics lesson, but this tended to be general support and not usually focused on mathematics learning. Few LSAs have had training to support mathematics learning. Two departments have sent teaching assistants to the training for primary mathematics last year and are drawing up a programme for supporting year 7 pupils linked with Springboard 7.

6. Heads of department. Heads of mathematics all have non-contact time to carry out their role, but this is often taken up with organising cover or teaching classes without a teacher. Heads of mathematics are spending increased time organising cover, maintaining staff morale and often teaching larger classes than other colleagues in the department.

The recruitment of mathematics consultants for KS3 has also depleted the number of effective heads of mathematics. Many head teachers have asked how they are expected to implement the strategy when they no longer have a head of mathematics. Some authorities have appointed part-time consultants to try to alleviate the situation.

Possible solutions

A variety of strategies are being adopted to try to increase the number of mathematics teachers and retain those in post. These include School Centred Initial Teacher Training (SCITT), the Graduate Teaching Programme, mathematics conversion training, the provision of leading mathematics teachers and continued professional development courses.

Some areas have SCITT schemes which provide a small number of mathematics teachers. These teachers tend to remain in one of the schools in which they trained which has advantages for the school but may not contribute to their professional development in the longer term.

The Graduate Teacher Programme has not been as successful as it was hoped. A number of trainees were left without appropriate support and training and have left the Programme. Middle-school teachers are being encouraged to undertake conversion training to teach through KS3 and KS4. Primary leading mathematics teachers have been asked to retrain as secondary teachers.

The NNS in primary schools and the mathematics strand of the KS3 strategy provide leading mathematics teachers. These teachers teach a number of mathematics lessons a term, which other teachers can observe. They teach their own class in their own school. They provide visiting teachers with a brief outline of the lesson and often a copy of their planning prior to the lesson and then spend 15 to 20 minutes discussing the lesson after it has finished. This aspect of the NNS and the KS3 mathematics strand has had a significant impact on the approach to teaching and learning mathematics and on the attitude of teachers towards mathematics. Both primary and secondary lessons have provided much needed rejuvenation, inspiration, and confidence: colleagues have been impressed with the standards of attainment, the positive attitude and confidence of the pupils. Teachers have returned to their departments feeling more confident that they can teach an interactive three-part lesson.

The Building Bridges project is just one example of a professional development project which developed from an inservice course for the use of the QCA Bridging Units. Secondary teachers and their partner primary teachers meet to discuss the mathematics teaching and learning which takes place at the end of Year 6 and the beginning of Year 7. There is discussion and study of the Year 7 and Year 6 schemes of work. The difficult discussions about pupils' perceptions of what they are taught in Year 7 and teachers' perceptions of what pupils were taught in Year 6 take place.

The most powerful aspect of this project is the visits teachers make to each others' classrooms and the opportunity to talk to each other. The secondary teachers visit and observe mathematics lesson in the summer term of Year 6 and the Year 6 teacher visits the secondary lesson in the autumn term when their Year 6 pupils are now Year 7. The resulting discussion about ensuring continuity, attainment, planning lessons has lead to raised standards, a more positive attitude to transition, the continued attainment of pupils and teachers feeling that they are working together to improve mathematics teaching.

Summary

This preliminary work indicates that the shortage of mathematics teachers may be greater than it appears. Mathematics teachers are striving to provide mathematics education in an increasingly difficult situation. Schools are regrouping sets and classes, extending the responsibilities of teachers and teaching assistants and reducing the number of mathematics courses.

The possible strategies to increase the number of mathematics teachers have not been successful and if pupils are discouraged from studying mathematics beyond the compulsory stage future recruitment will remain low. The NNS and the mathematics strand of the KS3 strategy may provide ways to retain and develop the mathematics teachers in post, but this will not reduce the teacher shortage.

I have particular questions for NAMA which are of relevance to the wider mathematics community: what can NAMA do to help? what problems are faced by NAMA because of this shortage? how long will it be before we lack maths advisors?

These are the subject of further investigation.

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Learning Preferences of PGCE Students: Implications for Recruitment of Mathematics Teachers

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Abstract

Applications for entry to Higher Education have persistently shown marked differences between ethnic minority groups and marked gender preferences, particularly for mathematics and the sciences. One reason for these differential choices is suggested by research into learning preferences. This is examined in this paper, which reports on a large-scale study of the preferred styles of teaching and learning of undergraduates and PGCE students. Clear subject differences in these learning preferences were identified with mathematics students consistently at one end of the scales and English students at the other. Some implications of these findings for the recruitment of mathematics teacher training students are discussed. The author would like to acknowledge that the research reported in this paper was carried out by Janis Jarvis at Manchester Metropolitan University.

Introduction

Table 1: Ethnic origin of accepted applicants, by subject group, 2000 entry (Percentages, cf.1996 entry)

	ASIAN		BLACK		WHITE		TOTALS	
	Men	Women	Men	Women	Men	Women	Men	Women
Medicine/Dent.	5 (6)	5 (6)	1 (1)	1 (1)	1 (2)	2 (2)	2 (2)	2 (2)
Sub. allied med.	5 (6)	10 (9)	6 (3)	10 (6)	5 (2)	9 (7)	5 (3)	9 (7)
Biol.sciences	2 (4)	6 (7)	2 (3)	4 (5)	4 (5)	7 (7)	3 (5)	7 (7)
Maths/informatics	33 (21)	12 (9)	22 (18)	8 (7)	13 (11)	3 (3)	16 (13)	4 (3)
Eng'ing and Tech.	10 (14)	2 (2)	12 (17)	2 (2)	10 (13)	1 (2)	10 (13)	2 (2)
Social studies	9 (11)	16 (18)	10 (13)	19 (22)	10 (11)	13 (14)	9 (11)	14 (15)
Languages	1 (1)	3 (3)	1 (1)	3 (3)	4 (4)	8 (10)	3 (4)	7 (9)
Humanities	1 (1)	1 (2)	1 (1)	1 (1)	4 (4)	4 (5)	3 (4)	3 (4)
Education	0 (1)	3 (3)	1 (4)	3 (6)	2 (7)	7 (11)	2 (6)	7 (10)
Combined sciences	4	3	3	2	2	2	3	2
Soc.st. with arts	1	3	2	5	2	4	2	4
Total Numbers	15552	14567	4312	5728	110828	129298	145177	163541

When UCAS first collected data in 1990 on the ethnic origins of applicants to Higher Education it posed a variety of questions about how students made their choice of subject (Taylor, 1993; Modood, 1993; Woodrow, 1996). It is clear that students from different ethnic groups have shown differential subject choices. The data in Table 1 (from UCAS Table G4) has been presented in terms of the percentage of acceptances from a particular group choosing a particular subject to study. Differences between the ethnic minority students and between genders are clear and persistent. Three times as many women study languages as men, six times as many men study engineering. Over 22% of Asian students (33% of Asian men) and 14% of Black students apply for Mathematics and Informatics compared to 7.5% of White students. This confirms a common perception that Asian students, in particular, are drawn to the subject, but so also are Black students. There are also interesting variations within ethnic groups (i.e. different Asian and Black groups) which have interesting features. Note however that the increase in recruitment to this group of subjects is very much to IT, mathematics recruitment remaining fairly constant:-

MATHEMATICS/INFORMATICS RECRUITMENT

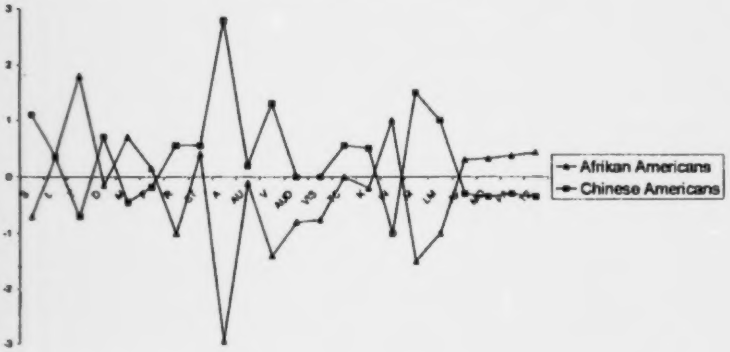
2000		1999		1998		1997		1996		1995		1994	
M	W	M	W	M	W	M	W	M	W	M	W	M	W
25195	6430	23119	5895	20214	5000	18089	4414	16327	3922	15244	3595	14664	3524
	31625		**29014**		**25214**		**22503**		**20249**		**18839**		**18188**

MATHEMATICS RECRUITMENT

2000			1999			1998
Men	Women	**Total**	Men	Women	**Total**	**Total**
2485	1567	**4052**	2402	1454	**3856**	**3925**

It is tempting to begin to draw speculative reasons to explain these differences, and some of these were explored in a previous article (Woodrow, 1996). The evidences for any particular explanation of these differential recruitment figures are not strong but the cultural milieu from which the students derive will have some effects. There has also been a long and significant debate about gender bias in respect of mathematics and science yet there seems little real movement. Woodrow (1996) suggested that learning styles have a significant influence. Indeed, for one group relating significantly to mathematics (the Chinese) Sham and Woodrow (2000, 2001) have shown that they strongly retain a very distinctive learning style to that of their White compatriots. For other groups there is little clear evidence in the U.K. relating to their learning styles, however, in a major exploration of learning styles in the USA Dunn (1990) contrasted African-Americans, Chinese-Americans, Mexican-Americans and Greek-Americans. She found significant differences, and in particular that African/Caribbean students had totally reverse preferences to Chinese students in 15 out of 21 learning preferences, such as working co-operatively or alone, working in the morning or evening, working in noise or quietness.

Learning Preferences : Chinese Americans/Afrikan Americans (after Dunn et al., 1990)



On subject choice and learning styles Woodrow conjectured that the way in which Mathematics is taught and learned might well select people with particular personal characteristics - authoritative, focused and convergent personalities - which might not be the most suitable for activities such as teaching (where interpersonal skills and adaptability are paramount). A small-scale survey of 38 students at the University of Lancaster reported in a DFE (1994) paper, relating to shortages of maths and science students, also conjectured that:

> Science and technology students liked the lack of essays, the highly structured courses, practical work, having an answer, being accurate and doing a vocational subject. They didn't like the fact that arts ' is all about learning' and studying in the arts was 'very isolated'
>
> Non-science based students disliked scientific subjects because they required extremely hard work, heavy reliance on experiments and practicals, emphasis on accuracy (too fiddly), full and inflexible timetables, few opportunities for self-development.

However what the subject-related learning styles really are and how they relate to subject variations in recruitment is still somewhat unclear. The current research project, described below, is designed to begin to explore these issues.

Learning styles

Individual differences in learning styles have been the focus of much attention from time to time, but there remains widespread confusion about the terminology used. However, the constructs themselves can be basically grouped into two main types of learning style. These are often distinguished as *cognitive style* and *learning preferences* and the underlying differences between these are essentially based on the degree of stability of the style within the learner and the bi-polar nature of cognitive style definitions. The most critical difference between different researchers lies in their commitment to 'stability' and in general one expects a cognitive style to be stable over time, whereas a learning preference might be expected to vary somewhat with context. Thus in the context of this enquiry ownership of a particular cognitive style might well lead a student to choose a particular subject to study, whereas a learning preference might well be imposed on a student by his/her choice of subject of study. In practice (like the nature/nurture debate) this is likely to remain an ambiguous dialectic. (For a more extensive debate on this see Jarvis and Woodrow on www.leeds.ac.uk/education-line.)

Approaches to learning

Currently, the most prominent area of research on this area of learning styles is based on the 'approaches to learning' model originating from Marton and Saljo's (1976) studies of 'deep' and 'surface' approaches. A deep approach consists of studying for its own sake, for personal interest and is meanings-related. A surface approach is essentially the opposite. It consists of studying to fulfil extrinsic demands and relying on memorising, whilst making little attempt to relate material to previous knowledge. Skemp (1977) identified a corresponding relationship to 'understanding' in his discussion of relational understanding (built upon a search for relationships and meaning) and instrumental understanding (a more functional learning of techniques and facts).

Choosing the instrument for enquiry

The focus of this study is on both learning preferences as conceptualised by the approach to learning model (using the Biggs' (1987) model of questionnaire) and cognitive aspects of learning represented by a student's regulation of learning processes and beliefs about knowledge. The interrelationship of these cognitive aspects with strategic leaning preferences is thus explored. In order to do this a new instrument was devised, incorporating approaches to learning questions with others directed towards epistemological beliefs and regulation of learning. Little is known about how students adapt their learning styles in a real educational context. The nature of different academic disciplines lend themselves to particular learning styles and the study reported here is also concerned with the subject specificity of certain learning preferences.

Disciplinary differences in learning

There has been some research into the categorisation of different academic subjects; one of the most widely used taxonomies is one devised by Biglan in 1973. He distinguishes between 'hard' and 'soft' subjects based on the paradigmatic basis inherent within each subject. Those subjects that have a single paradigm, or hard subjects, would be more fixed in content as areas of interest and research methodologies are usually agreed. Subjects without a paradigmatic basis, or soft subjects, have idiosyncratic contents and method with no consensual area of study or research. Under this classification, maths and science are hard subjects and humanities and social sciences soft. Subjects like business studies which appear towards the middle of the continuum are said to be 'striving for a paradigm' (Biglan, 1973).

These subject differences appear in the way they are taught and learned. There is widespread belief that maths, foreign languages and sciences are characterised by more teacher-led methods than arts, humanities and social sciences. The DES reported in 1972 that Mathematics and Modern Foreign Languages were the most problematic subjects in the moves then being made towards mixed ability teaching. The criteria for success in the hard subjects are often more straightforward with an emphasis on right and wrong answers. One can easily see a link between cultural philosophies which emphasise respect for authority and the attraction towards subjects that allow students to more easily reinforce expert knowledge.

It is well reported that teachers' strategies for managing their classrooms are inevitably subject-specific but there is little research concerning the learning preferences of students within different subject areas. It seems likely that those studying soft subjects will incline towards the more interactive techniques while an acceptance of the teacher as authority is more likely to occur in the hard subjects. Similarly, stereotypes suggest talent or natural ability are necessary for success in maths, languages, music and art, whereas effort and effective study strategies are more likely to signify success in social science or humanities. These notions affect students' perceptions of their ability and self-esteem. A student performing badly in a maths test is less likely to attribute a poor result to lack of effort and success or failure is seen as beyond personal control. This fatalistic attitude will be reflected in the undervaluing of self-regulating study techniques which are then seen as having little effect on achievement outcomes.

The study looks at the interrelationship of four aspects of learning: *approaches to learning, interaction, beliefs about knowledge* and *regulation of study strategies*. It is only possible to speculate on whether any preferences are developed as a result of the subject matter or whether personal predisposition has led the individual to move towards subjects which reflect his/her preferences.

To measure these different dimensions of learning preferences an instrument for self-completion was developed which made it possible to express each of the four aspects in a summated score. The questionnaire as a whole contained items relating to biographical details as well as a section of items referring to preferred methods of learning which were to be ranked in order. The largest section of the questionnaire, though, was a 50 item 4-point Likert scale. The items were subjected to item analysis and factor analysis which resulted in the identification/confirmation of the four dimensions mentioned above.

The sample

The sample consisted on a total of 867 students, 483 were working towards their Postgraduate Certificate in Education and were studying in a broad range of subject areas, English, Art, Geography, Music, Social Science, Maths, Business Studies, Design and Technology, Physical Education, Religious Education, and Modern Foreign Languages. The other 384 students were undergraduates, mostly in their first year of study in five specific areas, English, Art, Business Studies, Science and Maths. Of the PGCE students 155 were male and 328 female. The undergraduates consisted of 199 male and 185 female students.

Questionnaires were distributed to students studying for their PGCE at the Manchester Metropolitan University and to undergraduates studying at several different universities country-wide including Keele, Bristol, Nottingham and Manchester. Response rates varied and in most cases the co-operation of a tutor was required to obtain results in sufficient numbers.

Results

The mean scores for students have been calculated within each subject area and for the four dimensions of learning preferences as well as the learning preference scale overall. The lower the score on a scale from 1 to 5, the greater the inclination towards a deep approach to learning, a relativist view of knowledge, a preference for interactive techniques and self-regulation of study.

Dimension 1: Approach to learning

The overall results for the PGCE students show a clear division between the soft subjects, English, Art and Humanities with lower scores, and the hard subjects of Maths, Science and Languages with the higher scores. The exceptions are PE and RE students with higher scores, but the sample for these subjects was small. The position of Business Studies and PE students has been determined to some extent by their tendency to be more extrinsically motivated than the other students, while Maths, MFL and DT students showed a particular tendency to prefer exact instructions from their tutors.

Table 2: Mean scores by subject - Approach to Learning

PGCE students

Subject	N	Mean	Std Dev
English	88	2.9593	.5131
Art	52	2.9952	.6510
Music	11	3.1136	.6415
Social Science	14	3.2798	.4788
Geography	32	3.2891	.5927
DT	49	3.3282	.5957
Science	94	3.3484	.5409
Mathematics	49	3.3622	.5617
Business Studies	33	3.3813	.6916
MFL	36	3.4468	.6384
PE	9	3.5185	.3904
RE	16	3.6094	.5062
Mean	(483)	3.2490	.6010

Undergraduate students

Subject	N	Mean	Std Dev
Bus.Studies	75	3.3369	.3929
English	75	3.3493	.5724
Science	89	3.3573	.5266
Art	47	3.4547	.2943
Mathematics	98	3.4611	.4436
Mean	384	3.3902	.4691

The undergraduate scores show a smaller spread in scores although they are generally higher than PGCE scores. However, whilst the two sets of scores cannot be indicative of developmental tendencies because the study is not longitudinal, the results would suggest that Maths, Science and Business Studies PGCE students do not use a significantly deeper approach to learning than their undergraduate counterparts. English and Art PGCE students however are much more inclined towards a deep approach than the undergraduates. This would suggest that the ways these subjects are constructed might have an influence on the approach used. The one surprising comparison was that postgraduates were more extrinsically motivated (by exam success) than the undergraduates (perhaps because the ITT context is now so target driven). If postgraduate students had responded as the undergraduate students on this issue then their scores on this dimension the difference in scores between the two groups would have been even greater.

Dimension 2: Beliefs about knowledge

The relative scores in the different subject areas are very similar to the *approach to learning* scale.

Table 3: Mean scores – Beliefs about Knowledge

PGCE students

Subject	N	Mean	Std Dev
RE	16	1.9375	.4106
Art	52	1.9973	.5212
Social Science	14	2.0306	.4986
English	88	2.0373	.4723
Music	11	2.0779	.4922
PE	9	2.1429	.6349
Geography	32	2.2232	.4881
Business Studies	33	2.2771	.5669
Science	94	2.2857	.5907
DT	49	2.3499	.5298
MFL	36	2.3889	.6801
Mathematics	49	2.5510	.4957
Mean	483	2.2195	.5607

Undergraduate students

Subject	N	Mean	Std Dev
Bus.Studies	75	2.2971	.5133
English	75	2.3981	.3405
Science	89	2.5169	.5560
Art	47	2.5973	.4061
Mathematics	98	2.6509	.5482
Mean	384	2.4948	.5408

The soft subjects, English, Art and Social Sciences have the lower scores and the hard subjects, Maths and MFL, have the highest scores. This indicates that students of hard subjects are more inclined towards a belief in the transferability of a body of knowledge and are more concerned in acquiring detailed information than general ideas. Undergraduates had higher scores than their PGCE counterparts but again the difference in scores between the Maths PGCE and undergraduates is minimal and the biggest differential is between English PGCE and undergraduates.

Dimension 3: Interaction and Participation

Table 4: Mean scores - Interaction and Participation

PGCE students

Subject	N	Mean	Std Dev
English	88	2.1006	.5547
Business Studies	33	2.1602	.6186
PE	9	2.1746	.4859
Art	52	2.1813	.4694
Science	94	2.2128	.4983
MFL	36	2.2540	.5194
Geography	32	2.2656	.6395
Social Science	14	2.2908	.3856
DT	49	2.3440	.6135
Music	11	2.4156	.5400
Mathematics	49	2.4738	.6418
RE	16	2.5804	.5648
Mean	483	2.2501	.5624

Undergraduate students

Subject	N	Mean	Std Dev
English	75	2.5758	.5502
Art	47	2.5850	.3334
Bus. Studies	75	2.5951	.2813
Mathematics	98	2.7744	.4835
Science	89	2.8843	.5492
Mean	384	2.6936	.4782

PGCE students and undergraduate students studying soft subjects are much more likely to interact and participate in the classroom than those studying hard subjects. The non-consensual basis of soft subjects means that there is likely to be a greater degree of uncertainty and debate within the content whereas students of maths and science have a firm paradigmatic basis which is much less open to criticism and argument. Students of hard subjects may be reluctant to question their instructors, but in other aspects of participation, for example, giving presentations, maths and science students were more likely to enjoy taking part than social science students. This leads to the speculation that enjoyment of discussion and sharing opinions is more related to the context than the personal predisposition of the student.

The relative positions of undergraduate results echo those of the PGCE students although generally PGCE students interact more.

Dimension 4: Regulation of study strategies

Students of hard subjects relied much more on external regulation than students of soft subjects. They showed a reluctance to look beyond their tutors and lecturers for explanations and information. English and Art students on the other hand, were more likely to take control of their own learning by reading round their subject and discussing lectures with their friends.

Table 5: Mean scores – Regulation of study strategies

PGCE students

Subject	N	Mean	Std Dev
English	88	2.1676	.5453
PE	9	2.2083	.3590
Art	52	2.2332	.5920
DT	49	2.3367	.5193
Science	94	2.3378	.5372
RE	16	2.3594	.5606
MFL	36	2.3611	.5854
Business Studies	33	2.4015	.6795
Geography	32	2.5000	.6091
Social Science	14	2.5179	.6276
Maths	49	2.6862	.6541
Music	11	2.6932	.4689
Mean	483	2.3592	.5890

Undergraduate students

Subject	N	Mean	Std Dev
English	75	2.4417	.5629
Bus.Studies	75	2.6117	.3405
Art	47	2.6512	.3058
Mathematics	98	2.8362	.5565
Science	89	2.8427	.5197
Mean	384	2.6941	.5096

PGCE students generally had lower scores than the undergraduates indicating that they were more likely to regulate their own studies, however, the differentials again are the least between maths PGCE and undergraduate students.

The overall learning preference scale

Table 6: The mean score for the whole scale

PGCE students

Subject	N	Mean	Std Dev
English	88	2.3568	.2825
Social Science	14	2.5167	.2980
Art	52	2.5481	.3009
MFL	36	2.6040	.3362
Science	94	2.6305	.2883
Geography	32	2.6368	.3621
Business Studies	33	2.6592	.4148
Music	11	2.6631	.3164
RE	16	2.6786	.2736
PE	9	2.6903	.2317
DT	49	2.7282	.2762
Maths	49	2.8242	.3656
Mean	483	2.6019	.3402

Undergraduate students

Subject	N	Mean	Std Dev
English	75	2.7556	.3608
Bus.Studies	75	2.8388	.1537
Art	47	2.8528	.1174
Science	89	2.8672	.2869
Maths	98	3.0190	.2607
Mean	384	2.8768	.2755

Maths students overall are shown to use a more surface approach, have a more dualist view of knowledge, interact less and are less inclined to self-regulate their studies than any other students whilst English students appear consistently at the opposite end of the scale.

Overall the learning preference scores of undergraduates are higher than those of their PGCE counterparts but the difference between the scores is greatest for English students and least for Maths students. Generally, students of soft subjects have lower scores than those of hard subjects with Geography and Business studies students in most cases appearing midway between the extremes. Science is usually conceived as a hard subject but in the results presented here it appears that Science students have learning preferences which are more similar to Humanities students that to Maths students.

General and domain-specific learning preferences

As expected the results from the study show that surface learning, external regulation, belief in transferable knowledge and less interaction in the classroom were more common among students in the hard subjects, particularly maths. The results were consistent in both samples of students. The level of study affected the results in that PGCE students were generally more inclined towards deep learning. The relative positioning of academic subjects on both sets of results reflects the underlying influence of context on students' learning preferences. The choice of the postgraduate students to pursue a teaching career means that they form a unique group and so the apparent developmental nature of learning preferences cannot be assumed from these results, but it may imply that for hard subjects like mathematics a smaller proportion of the cohort (those towards the deep learning end) are available for recruitment to teaching.

Soft subjects attract a greater proportion of female students and the PGCE sample in particular consisted of 68% female students. However when comparisons were made between male and female students across the whole sample, the scores were very similar with the exception of a small difference in the regulation of study score which indicated that females are slightly less likely to be externally regulated. This lack of 'gender' related learning preferences was somewhat of a surprise, and it suggests that whereas learning preferences may well be one significant factor in groups of students choosing their academic career subjects, there are clearly other factors which enter this equation. In particular there still exist strong gender related perceptions of certain subjects which are seen as 'male' subjects and others (including education) which are seen as 'female' subjects. What it did confirm, however, was that the variations found between subjects were indeed subject related and not a consequence of the differing gender balances between subjects.

The consistency of the results across all four dimensions indicates that there is a relationship between them and that a low score on one dimension is likely to be accompanied by a low score on the other dimensions. Clearly these are also directly related to the subject being studied. However, the underlying dimensions, whilst functionally interdependent, are distinct and the intention is not to speculate on cause and effect relationships.

Preferred methods of learning

Students of different subjects were asked to rank in order the method of learning they felt was best for them. They were given a choice of six different methods that represented interactive, independent and transmission methods of teaching. Ranked in order of preference, the results are as follows.

Table 7: Preferred methods of learning in rank order – PGCE

PGCE subject	Talking and discussing	Doing own research	Reading books	Hearing explanation	Doing Problems	Memorising and practising	Learning from mistakes
English	1	4	2	3	6	7	5
Soc Sci	1	5	7	2	3	4	6
Art	1	5	7	4	3	6	2
MFL	2	7	5	1	4	3	6
Science	1	4	6	3	2	5	7
Geog	1	4	5	2	3	7	6
Bus. Stud	1	6	7	2	3	5	4
Music	1	4	7	2	5	3	6
RE	1	2	3=	3=	5	7	6
PE	1	7	6	3	2	4	5
DT	1	6	7	2	3	5	4
Maths	2	7	6	3	1	5	4

Table 8: Preferred methods of learning in rank order – undergraduates

U/grad. subject	Talking and discussing	Doing own research	Reading books	Hearing explanation	Doing problems	Memorising and practising	Learning from mistakes
English	1	4	5	2	3	6	7
Art	6	4	5	2	1	3	7
BusStud	4	1	6	3	2	5	7
Science	3	7	6	2	1	4	5
Maths	4	7	6	2	1	3	5

Teachers' conceptions of their subjects differ and this affects the amount of freedom that they perceive is available for innovative teaching. English teachers, for example are likely to experience greater autonomy in their choice of content and are able to be flexible in their approach while teachers of maths and languages are more likely to feel they must cover the content of their curriculum in a specific order. Most research on teaching methods concentrates on the introduction of more interactive methods but students themselves have clear ideas about the best way of learning particular subjects.

The most popular method of learning amongst all students, PGCE and undergraduate was talking and discussing with notable exceptions. Maths students felt they learned better by doing problems than talking and so did the Science and Art undergraduates. Undergraduates were much more likely to prefer methods that are more associated with the transmission model of learning, hearing an explanation and doing problems as the following table shows. English students are more likely to feel they can learn independently by reading books and doing their own research than Maths students and along with Arts and Humanities students gave a low ranking to memorising and practising.

Perception of teachers

Student ratings of teaching have been found to differ systematically in relation to academic discipline. Students tend to rate teachers of art and humanities higher than teacher of maths and science. This is directly associated with a student preference for interactive behaviour regardless of subject being studied and was more evident in the soft subjects (Franklin and Theall, 1992). Although this research found that most students agree on what makes a good teacher, there were also differences between students studying in different subject areas which indicate an appreciation of the constraints and possibilities of teaching within their own subject.

Kember and Gow (1994) identify pastoral interest (talking and listening) and motivation (creating enthusiasm and excitement) as being characteristics of facilitative teaching whilst a good knowledge of the subject and organisation enabling a clear structure of the subject to be taught as characteristic of the transmission model. It would therefore be expected that these teaching orientations would be associated with the learning preferences of students. Students studying in areas where there was a greater inclination towards a deep approach would favour those characteristics associated with learning facilitation (in this study identified as 'easy to talk to', 'listens' and 'is good fun'). Conversely those inclined towards a more surface approach would favour the characteristics associated with the knowledge transmission model (identified in this study as 'knows the subject', 'is organised', 'gives good notes' and 'keeps control of the class'). Students were asked to rank in order what they thought made a teacher they most respected good at his/her job.

It seems that all students most respect a teacher who knows the subject and is organised though they also all want a teacher who is easy to talk to. Maths PGCE students most respected a teacher who was easy to talk to, perhaps reflecting the perceived difficulty of their subject. Maths undergraduates ranked 'gives good notes' the highest. The differences between A-level maths and HE maths have often been reported as representing a shift in beliefs about the nature of maths from algorithmic techniques to argumentation as objectives move from solving problems to constructing proofs. This may be the reason for the change in preferences between

Table 9: Rankings of Teacher characteristics by subject: PGCE

PGCE subject	Knows the subject	Is organised	Easy to talk to	Listens	Keeps control	Gives good notes	Is good fun
English	1	2	3	4	7	5	6
Soc Sci	4	2	1	5	6	3	7
Art	1	3	2	4	5	6	7
MFL	1	3	2	4	6	7	5
Science	1	3	2	4	7	5	6
Geog	1	3	2	6	7	5	4
BusStud	2	3	1	4	6=	5	6=
Music	1	2	3	5	4	6	7
RE	1	2	3	4	7	5	6
PE	2	1	4	6	7	5	3
DT	1	2	3	5	6	4	7
Maths	2	3	1	4	6	5	7

Table 10: Rankings of Teacher characteristics by subject: undergraduates

Und'grad subject	Knows the subject	Is organised	Easy to talk to	Listens	Keeps control	Gives good notes	Is good fun
English	1	2	3	5	7	4	6
Art	1	4	2	3	7	5	6
BusStud	1	4	2	5	6	3	7
Science	1	5	2	4	7	3	6
Maths	2	4	3	5	7	1	6

undergraduates, early in their studies, and PGCE students having completed their H.E. studies. Undergraduates did not want a teacher who was fun but PE and Geography PGCE students thought it was important. Overall PGCE students ranked 'being organised' over 'gives good notes' with the exception of Social Science students. Science, Maths and Business Studies undergraduates all ranked 'gives good notes' over 'is organised'.

Preferred learning environment

There are many learning environments at Universities, some of which require more interaction than others. Lectures usually are directed at large audiences and require little student participation so it would be expected that students familiar with non-interactive environment would prefer these to seminars and workshops. Students of subjects that are thought to be difficult to learn alone, like maths, would not be likely to prefer individual research. The research explored this theory by again asking students to rank their preferences in order.

Table 11: Preferred learning environment in rank order by subject: PGCE students

PGCE subject	Lectures	Seminars	Workshops	Individual Research
English	3	1	2	4
Soc Science	4	1	3	2
Art	4	2	1	3
MFL	2	1	3	4
Science	1	4	2	3
Geog	3	1	2	4
Bus Studies	3	1=	1=	4
Music	3	2	1	4
RE	1	3	4	2
PE	3	1=	1=	4
DT	2	3	1	4
Maths	1	3	2	4

Table 12: Preferred learning environment in rank order by subject: Undergraduate Students

Undergraduate. subject	Lectures	Seminar	Workshop	Individual research
English	3	1	2	4
Art	4	2	1	3
Bus Stud	3	4	1	2
Science	1	3=	2	3=
Maths	1	3	2	4

The results show that while students of the soft subjects prefer seminars, mathematicians and scientists prefer lectures. Those students of subjects with a more practical basis prefer workshops, though these generally proved more popular with undergraduates than PGCE students.

PGCE students

There are very few substantial studies which consider why students choose to take a PGCE course, though there are number of small interview studies of specifically mathematics students, some of which will be reported elsewhere in this conference. (See also Jones et.al., 2000 on students choosing a mathematics degree) There seem to be none at all which look at different reasons students from different disciplines may have for deciding to enter teacher training. A better understanding of the reasons students have, and particularly those in shortage subjects, may help to direct recruitment strategies.

Recent research by Reid and Caudwell (1999) used questionnaire techniques to investigate PGCE students' reasons for choosing teaching as a career. Assessing responses to 21 different possible reasons ranked in importance on a Likert scale, found that the two most popular reasons chosen by 96% of the 453 students were that they enjoyed working with children and that they felt teaching would bring high job satisfaction. They distinguished between Arts and Maths/Science graduates but found little difference in the results, the greatest being that 40% of Arts students compared to only 17% Maths/Science students chose continuing their interest in their studies as important.

The results from the research reported here shows a different perspective in that the reasons for choosing a PGCE course were not restricted by pre-coded responses and so did not ask for opinions on a range of answers. By leaving the question open-ended, students were more likely to respond with their main reason, or the answer that was foremost in their decision. For analytical purposes the responses were grouped into six categories and these represent 93% of all responses. The remaining

7% gave reasons which did not fit into any of the categories and tended to be of a more personal nature. A small minority of students had no intention to teach, using the PGCE course as a stepping stone to another career such as educational psychologist.

The six categories were

Want a challenging/stable/rewarding career
Enjoy the subject/want to pass on love of the subject
Love of children/want to work with children/want to inspire young people
Always wanted to teach
Enjoy teaching
Change in career

The sample consisted of 492 PGCE students studying in 12 different subject areas. This sample contained the 483 students mentioned previously plus 9 extra RE students who completed a questionnaire at a later date.

The most popular response for all students was career-related with 45% of all students stating that they wanted a challenging, stable or rewarding career. However, when analysed by subject there are notable differences. 56% of RE students and 54% of Art students gave this reason but only 22% of PE students. This was also the reason given by 47% of Maths students and 38% of English students. The second most popular reason, in contrast to Reid and Caudwell's (1999) study, was a wish to continue with the subject. Again the highest proportion by subject was RE at 28%, followed by PE at 22%, but no Music students gave this as a reason. 16% of Maths students wanted to stay with their subject and 18% of English students.

Only 12% of the total sample mentioned a desire to work with children. This is very different to the response from Reid and Caudwell's (1999) study where 96% felt that working with children was an important factor. This highlights the differences in results which are obtained by using different methods. Wanting to work with children, whilst undoubtedly a factor in more than 12% of students' decisions to become a teacher, did not seem to be their prime motivation. Only 7% of English students, the lowest percentage, for example, specifically mentioned children in their response and only 10% of Maths students but at the other end of the scale 22% of Geography and PE students mentioned either a love of children or wanting to work with children.

10% of the sample replied that they had always wanted to teach. This was the only response where there was a large discrepancy between the genders with 4.5% of males expressing this view and 15% of females. This is likely to distort the subject figures where 23% of English students gave this reason. There is a high proportion of female students in the English sample. The reason for the gender differences is likely to be due to women considering careers which will ultimately fit in with family life and some female students did mention specifically wanting a career that would fit in with having children. However only 5% of Modern Foreign Language students, 86% of whom are female, replied that they had always wanted to teach and only 6% of Maths students. None of the Business Studies students or PE students gave this response.

Some students had previous experience of teaching and so were able to respond that they had enjoyed teaching and wanted to formalise their qualifications. This response was given predominantly by Music students (36%) and PE students (33%) but these are subjects where there are more opportunities to teach without a PGCE.

4% of all students stated that their reason for choosing a PGCE course was that they were changing their career. There were big differences here in the subject areas with 16% of Maths students giving this reason. The other subject areas which were well represented in this category are Business Studies, DT and Science. Only a very low number of student in other subjects gave this reason.

The six reasons given above for choosing to take a PGCE course can be broadly divided into vocational and career-related, with a love of the subject, always wanting to teach and wanting to work with children being the more vocational responses. If divided in this way, then 38% of students had vocational reasons for choosing a

PGCE course. Perhaps of more relevance though to the subject specificity of these choices is that a familiar pattern emerges with more English and Humanities students being motivated for vocational reasons than Maths students.

Table 11 Percentage of PGCE students giving vocational reasons for their choice

Subject	Percentage
Geography	50%
English	48%
RE	48%
Social Science	45%
PE	44%
DT	38%
MFL	38%
Science	38%
Art	32%
Music	27%
Business Studies	27%
Maths	22%

There is a gender bias to the responses, however, with 45% of female students and 33% of male students choosing the more vocational reasons. This does not fully explain the differences in numbers though particularly as Geography and Maths are represented by almost equal numbers of male and female students.

The shortage subjects of Maths, Science, DT and MFL are worth considering separately. These subjects are most attractive to people wishing to change their careers and the influence of financial incentives must be a major factor. They tend not to be the subjects selected by students with more vocational reasons for taking a PGCE course and have often been characterised by the recruitment of mature students. This would suggest that financial incentives and an emphasis on career structure and employment security are likely to be more motivating for students in these subjects that more altruistically directed marketing.

More general comments

There are a number of reasons for students choosing or not choosing particular subjects, and similarly, for students choosing a teaching career or not. This study has looked at one potentially major factor on their decision making. What emerges – as it does from the recruitment statistics over the past thirty years – is the continuity and stability of the situation. In the period 1975-1985 when I collected statistics on maths teacher recruitment, there was a fairly stable output of about 1100 students – about 250 of whom were undergraduate B.Ed. students. This was against a target of about 2500 (based on a teaching force of about 25000 and an average working life of 9.35 years; see Woodrow, 1982). Examination of the many documents over the years shows that there has always been a shortfall and one has to ask why this has been less evident in the schools than might have been expected.

The 1986 DES document identified three levels of shortage:-

> **Overt shortage**: measured by unfilled vacancies.
>
> **Hidden shortage**: where tuition is given by teachers who might be considered as under-qualified
>
> **Suppressed shortage**: where a subject is under-represented in the timetable.

Having B.Ed. trained teachers concentrate on teaching KS3 rather than wanting to teach A-level was often useful, and many of these courses did encompass two-subject provision. Indeed, many PGCE courses were two-subject courses. This also provided valuable teachers of varying inclinations and skills: though the nature of the mathematics curriculum itself constrains the teaching act. The use of teachers of other subjects in teaching Key Stage 3 mathematics has always been a feature of staffing deployment – the Royal Society report of 1988 discussed how this might be more profitably managed and lead to an opening out of the mathematics diet in schools. The imposition of the current standards and inspection criteria on ITT has meant that such teachers are no longer prepared for two-subject teaching. Clearly there is an argument about the standard of mathematical knowledge required by teachers of mathematics, but there are potential organisational arrangements which could support a more mixed teacher cohort. The use of 'master' teachers to oversee a curriculum delivered by 'associate' teachers, in turn supported by technician assistance was hidden within the Royal Society 1988 report as potential solution. In the context of a 'nationally prescribed KS3 strategy it might be very attractive. It would again perhaps allow a wider range of skills to be recruited.

The issue of suppressed shortage is also now a realistic proposition. At the ICME conference last year in Tokyo the worries of the Japanese teachers that their time allowances were being reduced was echoed by delegates from a number of other countries. The increased possibility of the suspension of the National Curriculum in KS4 to enhance vocationally-based provision could well lead to mathematics being replaced, at least in part, by courses in basic/key skills with a different curriculum, an issue touched on by Diana Coben. Mathematics would effectively then become an option subject in KS4; releasing teaching time, or at least relieving some of the pressures.

Clearly we are unlikely to increase significantly the number of mathematicians we recruit to teaching . There are two responses to this, to recruit from other graduate markets (amending our expectations of expertise requirements) or to reorganise the way in which the mathematics teaching force is managed - or both.

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Problem? What Problem?

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Abstract

Successive administrations have responded to the serious shortage of competent mathematics teachers by trying to 'make do', or by adopting short-term strategies which fail to address the underlying problem. A sense of urgency, the will to act, and the imagination to see a way forward have been absent. The situation is now worse than ever. I offer a preliminary analysis based on the three distinct headings - (a) Recruitment, (b) Retention, and (c) Re-training. Though distinct, these remain interdependent (so should not be separated as in the DfES!). Each requires emergency short-term measures, and a long-term strategy - which must be compatible. My analysis leads to a number of conclusions and practical proposals. If these survive initial scrutiny, some could be implemented almost immediately, while others would require some preparatory work.

General background

There are times in life when it is hard not to despair. For those who care about mathematics, about schools, about teachers and about children, now would appear to be such a time.

Raising the quality of mathematics in schools depends to some extent on achieving a sound curriculum and on adequate resources. But above all it depends on having competent teachers, and on providing them with the 'space' which they need to teach well.

Education is based on a simple premise: since fashion is fickle, and since the present lasts no longer than the twinkling of an eye, the things worth passing on are those which have proved themselves to be of lasting value. Thus education has to be seen as a long-term venture, in which we lay foundations in the early years with a clear understanding of what will later be developed thereon. In particular, while the adult world may undergo change at an increasing rate, the education of our children cannot take place in a climate of continual upheaval.

The recent DEMOS report by Matthew Horne (Horne, 2001), which asserted that 'teaching has become an unsustainable profession', also notes that:

> **Contrary to popular opinion, teachers are not resistant to change in all forms... However, most teachers argued consistently that the government's education reforms meant that they had experienced change as a never-ending barrage of externally imposed and badly managed initiatives that they had little constructive role in helping to shape.**

In mathematics the situation is sufficiently serious that graduates with good degrees scarcely give teaching a first thought, while experienced teachers are retiring early in droves - with or without an agreed early pension.

Against this background, the raft of initiatives and up-beat claims in the recent white paper, *Schools: achieving success* (DfES 2001), contains more than a hint of the Queen of Hearts, croquet hoops and balls apparently in place, proceeding to declare the start of yet another inevitably victorious game, while failing to notice that the balls and hoops have all uncurled themselves, stood up, and wandered off.

In trying to make sense of the current mess, it may help to distinguish two separate issues.

First there is the (largely political) problem of acknowledging, and responding appropriately to, the short-term chronic shortage of mathematics teachers.

Second there is the professional challenge (facing the DfES, the TTA, and those from the wider mathematics and education communities in schools and universities) of devising some way to make sure that the short-term crisis does not become accepted as an intrinsically insoluble recurring theme.

One reason for making this distinction is the need to insist (i) that the two problems have to be tackled simultaneously, even if the first requires action on a shorter time-scale, and (ii) that no proposed response to the short-term political problem should be adopted if it seems likely to undermine progress in addressing the longer-term challenge.

Our discipline of Mathematics is a remarkable and increasingly important part of human life and culture. Thus we have to find ways of ensuring that those with the abilities and the inclination to teach mathematics in schools are encouraged to consider it seriously, without their being required to put up with working conditions which make it increasingly difficult to gain the simple satisfaction that comes from teaching mathematics effectively.

My main aim here is to attempt a thumbnail sketch of the longer-term challenge facing the profession. However, it is necessary first to indicate the extent to which inadequate and inappropriate responses to the short-term 'political' problem regularly undermine attempts to address the more serious long-term issue.

Recent events

The serious shortage of competent mathematics teachers has been evident for more than a decade. According to the DfE's own data [DfE Statistical Bulletin 24/93] a survey in January 1992 showed that less than 40% of those teaching mathematics in maintained secondary schools had a qualification (specialist degree or B.Ed.) involving an (unspecified) 'significant amount of mathematics'. When one allows for the fact that the corresponding figure for those teaching mathematics at age 16-19 was over 70%, it was evident that

> already in the early 1990s the percentage of mathematically qualified teachers at Key Stage 3 was embarrassingly low (around 25%),
>
> Ministers and officials were well aware of this fact, and that they chose to muddle through.

Those of us who sought to persuade the TTA to act were repeatedly confronted with a wall of ever more bizarre excuses as to why the problem was 'intrinsically insoluble'. The issue was further highlighted in the 1995 LMS report *Tackling the mathematics problem* (Appendix F). Yet, in seeking an accurate analysis of the nature of the problem, and an assessment of how it might best be addressed, Ministers and officials have consistently failed to engage in any kind of dialogue with the relevant sections of the mathematics and education communities.

Radical changes in schools continue to be rushed through without considering their inevitable impact on mathematics and on the supply and retention of mathematics teachers. And there appears to be no coherent strategy for systematically strengthening the mathematical competence of the tens of thousands of serving mathematics teachers who have a relatively weak mathematical background.

Not surprisingly, the situation has worsened.

From the outside it can sometimes seem that officials have become intoxicated by their own 'virtual' (= unreal) world of education. The future offers many exciting possibilities (of which 'curriculum online' may well be one). But all of these possibilities require more, and more competent, mathematics teachers. It is therefore worrying to find such possibilities being bandied about as though they offered some magic solution to the problem of teacher shortage. Instead of engaging with those who might help to solve the problem, the official 'virtual' world, with its consistently up-beat 'spin', is in danger of sliding into the Soviet-style belief that all problems can be resolved through central Diktat alone.

Though there are one or two more positive signs, the overall impression is that the government and its officials need to be reminded of that most basic of all principles: when in a hole, stop digging, make an honest attempt to take stock, and look for the most likely sources of help! In this respect the long-delayed white paper *Schools: achieving success* would seem to represent a missed opportunity. A whole chapter is devoted to 'Valuing and supporting teachers in schools'; but its tone and detail gives the impression that the authors have got hold of the wrong end of the stick (or even the wrong stick entirely).

The central issue was highlighted in the recent DEMOS report - cited above: 'Schools need to become more appealing places to work', so that teachers are systematically helped to become competent professionals, and so that the best teachers are content to continue in the profession.

As indicated by the 1992 data quoted above, any partial solution to the long-term challenge will require a more profound, and a more professional, analysis than crude appeals to market carrot-and-stick financial packages (such as 'Golden Hellos' linked to penalty clauses designed to force recruits to stay in teaching). We have to find ways to improve the quality and the mathematical background of entrants to the profession, and to provide effective supplementary subject-based training for those already in post. In particular, any solution will depend on a level of co-operation and commitment from the profession, which is only conceivable on the basis of partnership. And such a partnership can in turn only be developed by actively engaging the profession in formulating, and hence securing their commitment to, whatever strategy is eventually adopted. Yet the recent white paper remains reluctant to confront the scale of the problem:

> 7.9 Shortages. ... there remain shortages in some parts of the country and some subjects and this can be a particular issue for schools facing challenging circumstances.

Though in pure logic 'some parts' is not inconsistent with 'almost everywhere', the intended impression here is clearly to suggest little more than a minor 'blip' on a largely progressive horizon. In reality, without an adequate critical mass of competent teachers, recent 'improvements' are unlikely to be sustained.

Her Majesty's Chief Inspector is renowned for his disarming directness. Yet, unlike his predecessor, he does not make a habit of pursuing his agenda in public. Thus one has to assume that he would not have made his very strong public pronouncement (reported on 29 August 2001) about the seriousness of the teacher shortage facing schools unless he felt that the issue was being ignored by those who are officially responsible.

HMCI's forthright public remarks were followed by a report in the Daily Telegraph (2 September) that the new Minister for Schools was having second thoughts. Whereas back in July he had tried to deflect any suggestion of a crisis (perhaps as a result of placing too much trust in the briefing provided by the civil servants in his new department), on 2 September he was reported as conceding:

> There are vacancies. There are very significant pressures in quite a number of schools in quite a number of parts of the country. Schools are facing great pressures. I have seen lots of evidence of that over the summer.

His language contrasts refreshingly with the white paper - even if the Secretary of State (in a BBC Radio 4 interview a day or two before) had been somewhat more restrained:

It is true there is a shortage. It is true that head teachers haven't had the choice that they wanted.

Sadly, from our point of view, the most striking thing about all these general remarks is that they do not begin to acknowledge, or to address the additional difficulties facing mathematics. However, we have to hope (and in this, this conference has the potential to serve as a valuable catalyst) that officials can be helped to understand not only the extent of the challenge facing us, but that they have to engage urgently in co-operative discussion with those sections of the wider mathematical community who must be an integral part of any long-term solution.

A very brief analysis

The long-term challenge would appear to have three distinct components - none of which is entirely straightforward.

1. Recruitment (of unqualified applicants for initial teacher training courses, and of already qualified teachers who are not currently teaching).
2. Retention (of those teachers already in post).
3. Re-training (of those teachers whose mathematical background is weak and who either wish to teach mathematics, or who are already being required to teach mathematics despite their limited background).

None of these is easy, and all are urgent! Moreover, they have to be tackled together. For example, as one correspondent put it: to address the first (for example) without the second is 'like trying to fill the bath without putting the plug in'.

Nevertheless I shall briefly consider each of the three separately - in reverse order.

3. Of the 40 000 or so mathematics teachers at Key Stages 3 and 4, official figures indicate that perhaps 25 000 need extensive mathematical retraining. If these teachers are to do their job with confidence, knowing where the mathematics they teach leads and why it is important, then a substantial national retraining programme is needed.

Moreover, such a programme should be aimed at more than merely 'how to teach the national curriculum'.

Naturally such a re-training programme could also serve as a requirement for qualified teachers in other subjects who wish to re-train as mathematics teachers.

Given the lack of supply cover, such a programme could only be delivered during twilight sessions, during the vacations, or as part of a distance learning programme. Fortunately it is now possible to pay teachers to attend a series of such courses, to make the courses both demanding and rewarding, and to offer increments to successful participants as part of a coherent professional career structure.

It is essential that such courses deal with elementary mathematics in a way which guarantees competence in school mathematics, and which at the same time embeds the school mathematics to be taught in a larger context, so that teachers understand which approaches to particular topics offer the best long-term pay-off. Thus such courses need to be carefully planned and piloted (by suitable members of the mathematics and educational communities) before being rolled out and generally funded.

2. Retraining teachers with weak mathematical backgrounds could do much to increase the satisfaction they experience in their daily work, and so extend their careers. However, this is but one aspect of the requirement that we have to make schools 'more appealing places' for competent maths teachers to want to work in. Despite the (rather weak) claim in the recent white paper

> '7.8 It remains a priority to encourage good teachers to remain in the profession'

too many of the initiatives listed either miss the point, or look as though they will impose additional burdens on mathematics teachers. The central goal has to be to make things much simpler, so that maths teachers can concentrate on teaching mathematics better, with externally imposed disruption only where it is really needed. Thus classrooms need to be liberated from the bureaucratic stranglehold of recent years, so that teachers of proven competence can concentrate on teaching.

1. Recruitment to initial teacher training mathematics PGCE courses has fallen short of target for at least 10 years (and in 1998 dramatically so). Though preliminary numbers accepted for 2001 are up, they are still way below target replacement levels, and anecdotal evidence suggests that many of those who have applied to take a PGCE have little intention of ultimately going into teaching.

The medium-term challenge (given the serious shortage, the age-profile of mathematics teachers in post, and the need for more well-qualified entrants) is to find some way of recruiting 2000 or more PGCE mathematics students each year for an extended period.

The average number for the years 1991-2000 was 1270, so such a programme demands a massive increase.

Clearly it will take many years before any improvement in working conditions might help to increase recruitment. Hence we have to do more than simply wait and hope.

Moreover, training salaries and 'Golden hellos' may help to convince some of those who take not only a first look, but who pause long enough to get hold of, and absorb, the relevant information. But as strategies, they are too strongly focused on the individual. The scale of the problem is such that we have to adopt bolder, more systemic strategies, which enlist the help of institutions (such as universities), rather than depending on individual applicants.

I give four simple examples which, though not a complete solution, would help to change the culture in the most relevant undergraduate departments.

(i) University departments in highly numerate disciplines have to be encouraged to ensure (and should be rewarded for ensuring) that high quality presentations about the attractions of mathematics teaching are routinely made to their first and second year undergraduates as part of standard career information. These presentations should ideally be given by recent young recruits. It is not enough that such presentations take place 'somewhere on campus' - since only a small subset of those students who are almost committed are likely to find out about and attend such events. Presentations need to take place in the students' home department - preferably as part of some general provision that all students attend.

(ii) At present schemes which allow undergraduates to spend half a day each week in schools tend to be organised centrally within the university. To increase the number of participants in such schemes who come from mathematics departments, those departments should be encouraged to incorporate (and should be rewarded for incorporating) this activity - for credit - as a coherent part of some undergraduate module (see (iii)).

(iii) University departments cannot be expected to press students into considering teaching as a career. However, there remains a significant group of students who would consider teaching as a career if only they had the chance to think about mathematics as more than merely a technical discipline. Many of our students remember enjoying school mathematics in a way which does not easily transfer to lecture-based undergraduate courses. Many university mathematics departments have run modules which encourage second and third year students to take a broader view, and to reflect on the nature of mathematics. Some of these either consider explicitly such questions as how human beings learn mathematics, or provide scope for students to pursue such questions as part of a mini-project. Experience suggests that a significant number of those who take such courses discover an interest in teaching and go on to take a PGCE. Yet such courses are often harder to teach than ordinary lecture courses, and hard-pressed mathematics departments naturally view them as something of a luxury. Thus encouragement is needed if they are to keep such courses alive (see (iv)).

(iv) To encourage numerate university departments to take seriously the job of informing their students about mathematics teaching, individual departments should be given a substantial cash reward for each of their students who successfully completes a PGCE course. (Insofar as there is a visible correlation between this unforced outcome and the kind of activities mentioned in (ii), or the kind of courses in (iii), departments would then be free to draw their own conclusions and to act accordingly.)

These proposals are serious, and would be very easy to implement. But they can only be part of the solution.

To increase the number of students entering PGCE mathematics courses - in a climate where industry and commerce already employ most of those who graduate in numerate disciplines - it has been clear for many years that there is no alternative but to deliberately work to increase the number of undergraduates in highly numerate disciplines! Yet this obvious requirement (which has many other advantages) has scarcely been discussed.

And to increase the number of students in highly numerate disciplines, there is clearly no alternative but to work systematically to increase the number of students taking, and succeeding at, A-level mathematics.

We can - and must - consider all kinds of lesser strategies (such as implementing (i)-(iv) above). Yet any serious attempt to tackle the problem - rather than fudge the issue - has to begin by increasing the pool of 18year olds with A-level mathematics.

To understand the extent of the current absence of debate between government and the profession, one need look no further than the AS/A2 fiasco. The botched introduction of AS levels was declared by those in Westminster as intended to increase the uptake of subjects like mathematics. Many of us warned that the opposite effect was more likely - and even explained why: but our predictions fell on deaf ears.

Reports from schools and colleges indicate unambiguously that the current structure has led to a marked decrease in those wanting to continue mathematics in Year 13.

What is needed is neither a fudge, nor pressure on exam boards to set trivial AS level exams or to lower the grade boundaries still further. The reality is that the kind of material that is best taught at A-level cannot be taught, assimilated and assessed within 8 months.

The whole structure needs review. And carved over the door of the review room should be the slogan: 'Let no proposal emerge from here unless it will increase the number of students succeeding at A-level mathematics.'

Of course, this central goal will require in turn an increase in the number of A-level mathematics teachers. So the overall strategy will have to include emergency measures to recruit (and train) appropriate teachers. This may prove expensive since the most likely recruits may be relatively 'senior': one may have to buy back some of those who have retired early, and to retrain mathematically competent recruits who take early retirement after other careers. But it should certainly be possible. And whatever it costs, it will be far cheaper than the inevitable consequences of continuing to bury our heads in the sand.

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Mathematics? No Thanks –
Choosing and then Rejecting Mathematics

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Abstract

There appears to be an assumption that, if we only had enough teachers, the 'problem' of mathematics would be solved. This paper presents the results of a study of the attitudes, expectations and study intentions of students who have *chosen* to study mathematics in the Sixth Form. What these students say about mathematics offers a rationale for why students have been turning away from mathematics as an area of university study but, at the same time, recognises the cultural 'capital' that an 'A' level provides. While availability of sufficient, well-qualified teachers of mathematics is an issue, for these students it is certainly *not* dominant. Their reasons for choosing and then rejecting mathematics as an area of study are presented.

Introduction

In the debates about the shortage of mathematics teachers, there is an issue which has not been addressed. This is the worrying decline in numbers, internationally, of those opting to study mathematics after compulsory schooling and particularly in higher education. The Economist reported on the general situation in the UK:

> When it was revealed last week that 35% of Britons between 18 and 30 were now attending university, there was general applause…Odd, then, that so many universities are firing staff and shrinking capacity. The problem is student numbers. Last year, some 52 universities failed to meet their targets for student recruitment.
>
> (The Economist, 30.6.2001, p.34)

Simon Singh, in The Daily Telegraph (September 26, 2001) pointed to the specific problem with mathematics in an article entitled 'Is the number up for maths?' And, in The Times Higher Education Supplement of September 28, 2001, a report from Australia said:

> Australia will have no mathematicians working in its universities by 2012 if trends continue…The number of secondary-school students taking courses in physics, advanced mathematics and chemistry over the past 20 years has also fallen. The academy [of Technological Sciences and Engineering] says that if this decline continues, these subjects will disappear from the school curriculum by 2020. (p.12)

It was this issue, of lack of interest in studying mathematics at university, which was at the heart of a study that I did with lower Sixth (secondary) students who had opted to take mathematics as a specialist subject for their Advanced Level examinations. Since such students provide the core for future students of university mathematics, and consequently for future teachers of mathematics especially in secondary schools, it seemed to me that the observed trend exacerbated the already disturbing shortage of mathematics teachers.

The measurement of 'effective' schooling using the sole criterion of academic success (Hay/McBer, 2000) is not only inadequate (Brown et al., 2001), but such a measure fails to take into account how teachers and pupils feel and talk about themselves in relation to the learning of mathematics. These feelings are very likely, if not certain, to impact upon adult choices and functioning and may be one explanation for the trend referred to above. However, the literature suggests that, at present, the links between school understanding of achievement, 'ability' and 'confidence' are drawn very tightly. 'Ability' is taken as unproblematic and assessable in terms of achievement. The gendered relationship between confidence and achievement in school mathematics, has been argued throughout the research literature (see Clute, 1984: 56) but without the construct of 'confidence' being taken as problematic. For example, '[O]ne noteworthy finding that emerged from the Fennema and Sherman studies (1977, 1978) was that males in Grades 6 through 12 consistently showed greater confidence than females in their ability to learn mathematics. Initially those differences were not reflected in differences in achievement; however, for the older students, confidence in mathematics was a good predictor of performance for females but not for males.' (Leder, 1990: 19). In the U.S.A., Chipman, Brush and Wilson (1985), reviewing the work to date, found that confidence (coincident with enjoyment gained from mathematical experiences) was a crucial indicator for female participation in secondary and tertiary mathematics. My main purpose in undertaking the research being reported here, therefore, was to investigate the ways in which confidence was understood and interpreted by pupils and teachers engaged in mathematics by choice. That is, I was making an assumption that, for my purposes, 'ability' could be interpreted in terms of a combination of success in compulsory schooling and motivation enough to make such a choice.

Background

There is a considerable research literature in psychology which addresses issues of self-esteem, perceived self-efficacy and attributional style. Some of these studies have argued that it is possible to improve students' academic performance by manipulating their styles of attribution (e.g. Wilson & Linville, 1982). Other research has used Seligman's theory of learned helplessness to make similar points (Abramson et al., 1978). Social psychological research on gender and education has suggested that, as a consequence of differential expectations by teachers (Freiberg, 1991), girls have lower self-esteem than boys especially after adolescence. All of this work draws on the theoretical frameworks and methodologies of 'mainstream' social psychology, sharing a number of common assumptions about the nature of the self and the relationship between the individual and society. The findings of this research are contradictory and, in particular, definitions of 'confidence' vary across different studies and between different constituencies within a given context, e.g. teachers, male and female pupils and researchers. The relationship between 'confidence' and learning (e.g. of mathematics) appears to be more complex than the research findings, on which this thesis is based, seem to indicate. The thesis has been challenged for example by Kenway & Willis (1990) in respect of the subtlety of interactions between influences that are undetectable in statistically-based studies and the complexity, and shifting nature, of how these influences operate. To these, I would wish to add the absence of the voices of learners and the implications of potential conflict between teachers' and learners' constructions. I saw 'confidence' as a concept socially produced under different conditions, and was interested to investigate the various meanings associated with it, in the mathematics classroom, by female and male 'A' level students and their teachers.

> *In schools, the psychologistic notion of 'ability' is linked to achievement, even to the labelling of low-achievers as 'low-ability'. The link is persistently made,*

> *also, with 'confidence' in ways which can affect a pupil's self-image and consequent choices. The outcomes, in terms of mathematics, constitute sites of, for example, potential gendering and, as Stobart et al. (1992) pointed out, 'it is legitimate to question whether the current requirements and assessments of GCSE mathematics have yet fully tapped the enthusiasms and strengths of boys and girls' (p.8). In other words,* how far is low achievement a consequence of structural and curriculum factors which are successful in diminishing interest and motivation of many pupils for mathematics?
>
> *A further question emerges from more recent indications that, in some countries including the UK, the gap in mathematical performance between girls and boys at the end of compulsory schooling has almost been eliminated. However, this apparently increasingly equitable state does not appear to have affected the male/female ratio opting for higher levels in mathematics, e.g. Advanced level in the UK, where males continue to dominate and to gain more of the higher grade passes (Elwood, 1995). In a forthcoming paper about Australia, the authors point out that:*

> It is important to address some of the bigger issues that affect the participation and achievement of both males and females. Critical to this is solving the problem of appropriately qualified teachers at every level from early childhood to university.
>
> (Forgasz, Leder & Thomas, forthcoming)

It is, therefore, a legitimate question to ask, without being deflected by the ill-informed 'disadvantaged boys' lobby, *what structural and curriculum factors need to be addressed to ensure an adequate supply of teachers appropriately qualified for this purpose?*

I chose to work with 'A' level students because they have left compulsory schooling behind them and chosen to study mathematics as one of the subjects that they offer for entry to university or adult life. Therefore one would expect to find that their choice is motivated by some interest, sense of competence, or, at least, recognition that mathematics is a critical filter to the course that they proposed to follow. One is unlikely, or perhaps should be unlikely, to find an appropriately educated teacher of mathematics, certainly in the secondary school, who does not have an 'A' level in the discipline. Every learner's meaning-making is very personal and mediated through the cultural climate of the classroom. Consequently, I was interested in how 'confident' behaviour was understood in mathematics classrooms and whether, potentially, the meaning given to confidence in learning mathematics conflicted with its meaningful application in other environments (Burton, 1994).

I was interested in the possibility that ‘confidence’ itself, like mathematics, may have powerful connotations, which have implications for academic performance of girls and boys in schools rather than such performance being seen simply as a function of ‘expectations’. Whether pupils displayed classroom behaviours identified by their teachers as 'confident' or not, I expected that they would use the description 'confident' and be able, and willing, to discuss it in different contexts. Teachers, too, have criteria which they use to ascribe learning behaviours as 'confident' and identify pupils in their classes as in 'high' or 'low' categories. An investigation of the discourses would, I expected, provide diverse meanings and resonances of this term for students, and their teachers, in mathematics classrooms (Burman & Parker, 1994) and perhaps give an insight into how young men and women were defining themselves, and being defined, with respect to the learning of mathematics.

The study

Thirty sixteen-year-old students, who constituted all the lower Sixth Form pupils in four schools in a large industrial city, were interviewed . Two of the schools were single sex (one of each). All but two male students were interviewed in pairs, all single sex except for one. Thirteen of the students were female (six pairs and one female in the mixed-gender pair). In addition, I interviewed two teachers in each of three of the schools (in one, as a pair) and one teacher in the fourth school. This is summarised as follows:

School Number	Pupils	Teachers
1 (all females)	4 x 2	2 (pair)
2 (mixed)	2 x 2 (females) 5 x 2 (males) 1 x 2 (mixed)	2 (individuals)
3 (mixed)	1 x 2 (males) 1(male)	1
4 (all males)	1 x 2 (males) 1(male)	2 (individuals)

The pupil interviews were roughly thirty minutes in length, the teacher interviews all over one hour. The interview with the pupils began with the request to describe a 'normal' mathematics lesson, then a lesson that they had particularly enjoyed and one that they had not. Students were asked why they had chosen to study mathematics at 'A' level and also what the students who were *not* studying mathematics thought of their choice. They were asked about their reactions to their 'A' level course, what they proposed to do after they left school, how they would describe mathematics, how they worked at mathematics, how they felt about mathematics, how they learnt and how they understood 'confidence'. Finally, they were asked to suggest ways in which teachers could help or hinder their learning of mathematics. In this paper, I only address the students' responses relevant to future studies of mathematics, i.e. will they pursue mathematics after 'A' level? If not, why did they choose it for 'A' level? How did they describe mathematics lessons and success at mathematics? What kinds of classrooms did they prefer? and What might teachers do, and not do, that would improve lessons for these students? I conclude by drawing policy implications from what these students say.

Will the students undertake mathematics courses after 'A' level?

Of the thirty students interviewed, 22 unequivocally answered this question with a 'no'. These included 11 of the 13 females and none of the females indicated that they would be undertaking further studies in mathematics unless these were integral to their chosen course. Two males said that they would probably do 'something with computers'. Six of those giving an unequivocal 'no', five males and one female, said that they would 'stay in the Sciences' and James (School 2), who intended to do Physics, commented: '*I don't like just being taught straight maths, just numbers. I like it when numbers mean something*'. (All names are pseudonyms, chosen by the students). Of those students who did not reply with an unequivocal 'no', only one male had decided to study mathematics at university. The remainder were either undecided or had chosen a different career route, such as pharmacy or dentistry. This picture represents the situation across the country where only 4,000 out of 60,000 'A' level students choose mathematics; the decline of interest in studying mathematics is clearly demonstrated. So, why did they choose to study mathematics in the first place and what is it about their choice that influences them so negatively?

If they were not taking mathematics with a career requirement, why did the students choose it?

The students gave seven reasons for choosing to study mathematics at 'A' level, four of which were cited by only one, two or three students. The most frequently cited reason given was mathematics as a critical filter to other choices. Twelve of the twenty-six mentioned course or employment requirements. Katherine (School 2) said: '*I needed physics and maths to do the job that I wanted to do*' and Steven (School 3) pointed out: '*It gives you lots of options.*' However, another important reason for continuing with mathematics was the 'GCSE effect'. '*I was going to do history but then I decided at the last minute to take maths because I started to enjoy it at the end. We were doing coursework and towards the end of Year 11 I started to enjoy it more because I was understanding it more and realised where it could take you*' (Fred, School 4). Ten of the students mentioned enjoyment in Year 11, which, according to some of them, resulted in getting better GCSE grades than they had expected. Of these, nine said that they would not continue with mathematics after 'A' level and, the tenth, Steven (School 3), was undecided about what he would do but summed up by saying: '*The grade at the end is the only useful thing that helps you get on with the rest of your life*' and future studies of mathematics were very unlikely. Five students specifically described mathematics as their 'favourite' subject or mentioned 'enjoyment' and 'challenge' with respect to studying mathematics. Not one of these intended to pursue mathematics after school. There is a crucial lesson here for policy makers, which I will take up in the conclusion.

How were the mathematics lessons described?

In the main, mathematics lessons were unexciting. Students described a 'normal' lesson similarly to, for example, Cynthia and Jodie in School 1 who said: '*Taking notes and going through examples*'. In School 4, Andrew explained: *'Usually we go through examples, say like just an example of a question on the board with the teacher and then we're usually left to go through exercises on our own and the teacher's there to support us when we need any other support.'* Joe, in School 2, told the same story: *'Basically we work out of a book ...we are left to do the work and if we've got any problems then we ask the teacher.'* David (School 3) gave an uninspired picture of lack of motivation and dependency: '*I go into the lesson and sit down and get out my books and pencils and wait until the teacher tells me to start doing my work.*' When asked what led to success in school mathematics, this picture was maintained with the students confirming data gathered by other researchers (e.g. Boaler, 1997, Boaler, Wiliam & Brown, 1998) that achievement is dependent upon two things: memory, '*You have to remember all the formulas*' (Fred, School 4) '*It does my head in because we'll come to the other formula and I have to keep checking back in the book and everyone else is remembering it and it's a bit embarrassing sometimes when I have to keep checking*' (Mark, School 2) and work, '*Maths, it's always work, work, work*' (John, School 2).

What kind of classroom would the students like?

The students were quick to draw comparisons with classroom experiences which they had enjoyed in other subjects. David (School 3) liked: '*The whole class getting involved and it was team work.*' Asked: Has that ever happened in a maths. lesson? he replied: '*No, we don't do that*'. Steven, David's interview pair, said: '*I enjoy oral lessons, like group discussions and helping each other on topics.*' His response to the question: Do you have lessons like that in mathematics? was '*No.*' Joe (School 2), spoke for most when he said: '*Basically it is the same structure to the textbooks and you know you're going to be working out of this textbook. In other lessons sometimes you have a lecture about something and you have a go, or maybe it's a test paper or whatever. That's why we enjoy the practical in maths so much because it's the only time that we do something different.*' This reference to 'the practical' was born out by all the students I interviewed who, when asked to describe a lesson that they had enjoyed, either, in the case of four students, said something like '*They are all quite the same really*' (James, School 2) or described a lesson which was 'active' (15 students) in terms such as Clare, in School 1, used: '*There was one, what was it called, permutations and combinations, and we were using a game. We used a Mastermind game and we were all playing and we were all doing it together and going through it. It was more of us doing our own problem-solving and learning it by ourselves instead of them just teaching us*'. This lesson was clearly memorable (and special) as it was described in great detail by both the students *and* their teacher. Emma said: '*We keep asking her as well if she can do more lessons like that because it actually helped us to remember the theory as well as the idea of permutations. I think because there was the game and people were laughing and joking as well and it was all very relaxed.*'

The students, who had experienced (usually one) active lesson, were very articulate about what they had done and why it had been memorable. Fred (School 4) referred to the lesson which had been about friction: '*That was good because it kept your brain active because you weren't just sitting there listening to the teacher. You could see why it was working.*' John and Joe, from School 2, talked about practical experiments. Joe explained: '*There is like proper maths and there is real maths, and that was like real maths.*' Chris, in School 3, recalled: '*I really enjoyed when we started the topic on collisions in maths mechanics. I thought that was quite interesting and practical uses. You know, you find modern day things that can be* *applied to a lesson. So I thought that was quite interesting. That was probably my favourite lesson I have had.*'

Tied in to active lessons, were the students' experiences of coursework which Mark (School 2) explained: '*GCSE coursework was good because it wasn't just that you did the work and it was there. It was you investigated the work and you discovered why it happened and it wasn't just out of books.*' It is possible to associate with these remarks, those statements made by students which supported teamwork, group discussions and teacher-led discussion '*I do enjoy the lessons where the teacher's doing it and I have to input ideas along with the rest of the class*' (Andrew, School 4).

Most of all, the students were supportive of classrooms where they could work together. David (School 2) put it succinctly: '*We all work together so it helps to make you more confident. You get to help each other out, and if you're trying to explain to somebody else, it helps you to understand it yourself. Class discussion is really good, you get a lot out of it.*' When working in small groups, they preferred to work with friends and emphasised how important it was that: '*You have to be able to turn to someone. You have to have a relaxed atmosphere*' (Cynthia, School 1). At least half of the students made remarks of this kind. Louise (School 1) pointed out that '*It helps initially to start off with if you've got friends but of course as you go along because you're discussing with everyone you build up relationships with other people in the group.*'

Do's and don'ts for teachers

From the above, it can be seen that the students wanted their teachers to facilitate discussion, teamwork, a light-hearted approach, a relaxed classroom environment where you are not afraid of making errors. They told anecdotes to support the fact that they did **not** want to be put down, persistently asked the same question, made to look a fool or feel patronised, put into a position where others laugh at you, be thrown 'in at the deep end'. They felt that teachers should explain well, should not rush the work, should know what they are talking about and should be sensitive to students who are struggling to understand. None of this is surprising, nor even unexpected. It is, however, seriously disturbing that students at the most advanced end of the school are still making these kinds of comments about their teachers.

Conclusions and policy implications

These students have provided a rationale for why an option to study mathematics into university was not one that interested them. The loss of such students between the success of G.C.S.E. and the 'A' level course which is seen as '*a lot of work ...and it's also difficult*' (Cynthia and Jodie, School 1) is explained, in part, by the stigmatisation of the course as 'boring', '*sometimes we sit there and think why are we doing this. We'll never need it*' (Clare, School 1). Despite considerable evidence to this effect, we do not listen to the students as they describe their experiences. Nor do we hear them when they describe, very articulately, the kinds of learning experiences which are functional for them. We persistently impose fragmented, disconnected syllabi expected to be memorised and then regurgitated on public examination papers. Where the GCSE has been successful in providing students with a challenging, interesting and motivating means of learning mathematics through active, project-based work, this recently has been reduced in importance and is not emphasised as a central part of learning mathematics. Curiously, this is despite two recent developments. One is my own research which shows that mathematical researchers, in their own learning, pursue a problem-solving style of doing mathematics (Burton, 1999), and the other is the increasing use of project-style work in undergraduate mathematics (see MacBean, Graham & Sangwin, 2001). It is not that teachers are unwilling to create classrooms of the kind that the students value. They feel that time pressures, overfull syllabi, the huge leap between the expectations of GCSE and 'A' level and lack of an underlying epistemology which respects participation and creativity, rather than reproduction, precludes them for teaching in the ways that they would like to teach. These are the structural and curriculum factors to which my question, in the introduction, referred. The students who spoke to me have, I believe, made clear which factors *they* think should be addressed. In another paper I will present what the teachers say, a flavour of which is given above.

The situation outlined in this paper is an extremely serious one and not only because it explains a persistent shortage of candidates who will become teachers of mathematics. The power of the mathematical hierarchy to impose a syllabus and a learning style that most students find dysfunctional must, I believe, be challenged. There is absolutely no educational evidence to support the kinds of statements that mathematicians in universities and, consequently, the teachers who were their students, make about the learning of mathematics. The kind of statement to which I am referring is, for example, 'first a student must learn the basics'. On the contrary, there is now considerable evidence that students who learn mathematics in the style that the students I have quoted would like to use not only learn well but can make use of their learning in situations which are novel (see, for example, Boaler, 1997). This evidence in mathematical education is reinforced by the general educational evidence at both school and university level. Furthermore, the kinds of examinations that we present to our students are limited and constrained and can only give information about very narrow aspects of the syllabus and it's use. 'Our system of tests and examinations distorts our school curricula and produces results that are of limited reliability, and of doubtful validity' (Wiliam, 2001). Package together the syllabus, the pedagogical style and the assessment and we have a curriculum which appears to be ensuring that students vote with their feet and abandon mathematics as a potentially interesting area of study. Add to that the structural factors which ensure that mathematics becomes both inaccessible and unpalatable and the result, I am afraid, is not only a worrying shortage of mathematics teachers but also a mathematically illiterate population.

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Another Maths Schooling Crisis?

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Abstract

The author looks beyond the current shortage of mathematics teachers to an underlying crisis in how we present mathematics in the classroom. Looking back, broadly similar crises were addressed in 1962 and 1982. On both occasions 'new approaches' were launched to loud fanfares. Both turned out to be disastrous in the long run. Clearly we need a 'new approach' today, but it must be thought-through more carefully this time. The author argues that maths has been fundamentally depersonalised to 'something machines do' and that a meaningful response always needs to emphasise that maths has little value divorced from imagination. Machines will always do 'imaginationless' maths better than humans. But 'maths imagination meld' is needed by society and it can become a fascinating subject for most children in the classroom.

Is there a crisis?

The government is urging everyone to refrain from talking about a 'crisis in education' on the grounds that crisis-talk encourages experienced teachers to leave the service. It also puts a dark cloud over schooling, thus putting young people off training to be teachers. Yes, but two vital issues need to be addressed: (1) 'Is there a crisis in education or not?' (2) 'If there is a crisis, is this public knowledge?' In my view the answer to both questions is 'Yes'. If this is right, the government's efforts to suppress the crisis only make the situation worse, much worse. A crisis which is publicly recognised, and which the government visibly refuses to acknowledge, sends a message of panic denial and 'who-knows-how-hopeless the situation may be'. The public will judge that if the crisis is so serious that it justifies Official Lying, the crisis must be serious indeed. The bad news, then, is that there is obviously a 'crisis' in staffing schools, and particularly in maths. The good news is that a rumbling crisis of this kind has been around for forty years - since Bryan Thwaites convened the first SMP conference in 1962.

An on-going crisis

Everyone knows the long term causes of the on-going, rumbling crisis, namely that the computer age creates an insatiable appetite in government, higher education, research, industry and commerce for young people who are mathematically well educated and minded. The pool of talent, though, is like a reservoir which is far too small to serve the community's need for water. There are some definite exceptions to this, but broadly speaking those employers who have the resources to do so buy-up almost all the talent. Schools are forced to make do with a dwindling body of people willing to teach maths: people dedicated to teaching, or averse to industry or both; people who prefer to work with children; people who choose to teach maths mainly for the sake of the great sporting opportunities to be found in many boarding schools. It was like this in 1962 and it remains so today. So what can we do about it? Well, the crisis itself tells us that a subject that is in such demand must be pretty important. If government, industry, commerce, etc. value the mental qualities associated with maths so much, they must be self-evidently valuable. The outline of the answer is thus clear: let's bring out more clearly than before the true modern value of maths to pupils in the classroom –by developing a new kind of exciting school maths! The aim of a 'new kind of exciting school maths' will be to increase the total pool of young people attracted to, and nourished by, the mental qualities mentioned above.

Reviving school maths

It is the logical, the natural, answer to the problem: like a water-hungry community deciding to build a larger reservoir. And it ought to be possible, in principle, to do it, because mental qualities that are so highly valued must be capable of being presented - via suitable Brunerian simplifications - in the classroom. We need a form of 'new curriculum' which will allow this intrinsic high valuation to shine bright and strong in schools! So has anyone thought of doing this? Yes, Bryan Thwaites did this, in effect, in 1962. Cockcroft did this, in effect, in 1982. The enthusiasm engendered by SMP in 1962 was immense. A new dawn had arrived, and it appeared to many wonderful in that dawn to be alive! A bandwagon began to roll with apparently irresistible momentum, towards mostly pure abstract, maths in schools: sets, mappings, binary numbers, binary operations, topology, transformations, groups, fields, matrices, and so on. Schools were sent questionnaires asking when (not whether) they were going to switch over to 'New Maths'. SMP itself could not contain the enthusiasm it unleashed: numbers of rival brands of 'modern maths' appeared: Nuffield, Leicestershire, Shropshire, Manchester, South Wales, etc. Belief in 'New Maths' was never unanimous, though. Morris Kline, Polya, the present author (with Frank Budden), Robert Lyness (then Chief Inspector), Warwick Sawyer, Scott, Allanson, Hammersley and various others launched broadsides against it. It all burned brightly for about five years and then doubts began to accumulate. By 1972 René Thom had announced at the Exeter ICME that 'modern maths for schools' was based on a fundamental mistake: that of trying to get children to run mathematically before they could walk. Later in 1972 a meeting of maths tutors from the UK universities in Nottingham decided that the new curriculum had been a disaster. They judged it by the quality of the mathematical culture revealed in the freshmen and women beginning to arrive in their departments from schools. They didn't like what they saw. There had been too much hasty assimilation of abstract jargon, too little appreciation of the generality and resonances that underlay it. The operational basics had been badly neglected in this rush for abstract glory: and genuine mathematical thinking and reasoning was almost non-existent. So the first search for a new paradigm in school maths turned out to be a mistake.

Reviving school maths, Mark II

It took ten years for confidence to return sufficiently to try again. Then in 1982 Bill Cockcroft launched his report Mathematics Counts (HMSO). It took a radically different line from the earlier 'modern maths'. Now the catchword was 'practical maths', a much more down-to-earth affair. Children would not be rushed into high-level mathematical abstractions; rather they would be shown all kinds of punchy, credible, practical applications, which would encourage them to do it! This time enthusiasm was almost unanimous. At UEA in Norwich the local Branch of the Maths Association staged a meeting with Bill Cockcroft for teachers in the area. Around 400 teachers came, ten times the size of our largest regular attendance at that time. One of the bases for this almost universal support was that the new curriculum was not 'modern maths for schools'. It was so refreshing not to be trying to operate portentous abstractions which neither the teacher nor the pupils really understood (but which they had been brainwashed into thinking were the essence of maths in the 20th century). A key phrase of the Cockcroft dispensation was 'using maths to make things happen'. It turned (tried to turn) maths into an adjunct of practicality. Enthusiasm burned brightly for 2-3 years. I remember at that time visiting schools where ordinary unstreamed classes of 14 year-olds were so engrossed in the problems in the SMP booklets that they didn't notice that the bell had gone for break! Then, as in the late 1960s, it began to turn sour. Teachers who had been so interested in the new 'practical problems' in 1982 began to get bored after teaching the same material over and over again. I attended a large conference on practical maths in the classroom staged by the IMA in Coventry in 1989 at which a substantial part of the audience staged a kind of mutiny against the Mickey-mouse applications they were supposed to teach. They had nothing but scorn for some of the so-called 'practical problems' which had appeared in some exams that year. Mrs Thatcher herself had shown earlier at the Centennial celebrations of the Maths Association in 1972 that she had little time for 'theoretical maths'. So practical maths was cemented into the National Curriculum: with scarcely a thought that it might be just as much a mistake ---though of an opposite kind--- from the hyper-abstract school maths which had preceded it. Of course Cockcroft was not 100% in favour of 'practical maths', though this was the new element in the mix and was supposed to be the chief motif. Cockcroft also endorsed 'mathematical investigations', a sort of after-image of the formidably pure maths of the 'new maths' era. Some eminent pure mathematicians in universities gave these 'investigations' their blessing (a priceless imprimatur), and of course teachers of an egalitarian persuasion loved the non-judgmental regime you could operate under this banner. The fact that the imprimatur was given on a value basis in flat contradiction to the reality of the permissiveness of the egalitarian classroom was hardly noticed by anybody.

Contradictions in 'practical maths'

In effect, Cockcroft's prescription for the curriculum embodied an overall contradiction in the very term 'practical maths', because maths is simply not seen by anyone as an 'adjunct of practicality', except by some anti-intellectual ('practical') people in industry. In addition 'practical maths' was in direct contradiction to 'mathematical investigations', which supposedly showed the intrinsic value of maths as an end-in-itself. And mathematical investigations embodied an internal contradiction, because the permissiveness, which allowed teachers to praise almost anything a pupil produced, directly eroded the sense of maths as 'an intrinsic high end in itself'. So, in retrospect, the Cockcroft prescription of 1982 has turned out to be even more disastrous than the SMP prescription of 1962. It started with more universal support than SMP, but this was probably mainly a reaction against the strain of the ultra-abstract regime, which had been the status quo for twenty years. The modest goals set out by Cockcroft were music in the ears of teachers who had long been struggling to teach impossibly advanced abstractions. However, when it came to 'bringing out' the magic of mathematical applications in the classroom Cockcroft's prescription failed, once the initial newness of the material faded. (The chief schemes were SMP, Shell and Spode.)

Think before moving to Mark III

So, should we try again to craft a new curriculum capable of 'bringing out' the essential magic of maths ---in a form children and teachers can appreciate? I think we should, but only after fully digesting what went wrong both in 1962 and in 1982. As part of this process of digesting 'what went wrong' we need to look at the various things the term 'mathematics' means to different groups of people. It is no use 'bringing out' a form of 'mathematics' in the classroom that is not the form of ‘mathematics’ the average person needs or can be expected to appreciate. The errors of 1962 and 1982 reduce in the end to attempts to liven up (in the eyes of its own in-house experts) two special varieties of mathematics, first that of the pure research hierarchy, and second that of the industrial-applicable maths complex. But this so-called 'livening up' was on the in-house terms of its architects. This in-house basis won't do. As Prof. Jack Allanson said in the late 1960s, 'mathematics is too important to be left to the mathematicians'. This remark applies both to the pure and applied maths hierarchies. In 1982 the latter group thought 'their turn had come', but the result was just as bad as the previous attempt to introduce a 'new exciting version of maths' - as seen and chosen by professionals from the top. The last thing we need now is a third ill-fated imposition of maths from above; that is, an 'imposition' based on the values of an existing status quo. What school maths urgently needs is a 'new exciting version of maths' based on research into (a) what pupils can do, (b) what pupils appreciate and (c) what society (not a narrow hierarchy) needs.

A new interpretation of maths

There is such a 'new exciting version of maths'. A major scheme of this kind was crafted and thoroughly researched in the 1970s by the Mathematics Applicable project. It was based on an extension of Peirce's insight that maths is essentially 'the science of hypothesis'. Peirce thought of maths as being the pursuit of hypotheses in science and in mathematics itself, e.g. the hypothesis that there are no solutions of the equation $a^p + b^p = c^p$ for a, b, c, p as natural numbers >2. The main 'extension' of Peirce's insight, though, stretches this idea to embrace hypotheses about innovations in life, development and technology. From this perspective, then, mathematics is the activity we use to explore the predictable implications of promising ideas for innovations. Any proposed innovation - at the proposal stage - is an hypothesis: that this gadget or this set-up will bring real benefits in its wake. We can model such a proposed innovation with mathematics. This can then be studied to tease out the predictable implications of the idea. In this way we get a mode of mathematical activity embodied in 'projective applications', that is, applications to new, postulated circumstances. The educational relevance of this is clear. By looking at exciting, sometimes exotic, innovations of the kind that interest pupils, we are able to conjure-up a great deal of imaginative appeal, which then rubs-off onto the subject. This is the new, warmed-up vision of the subject we urgently need to recapture interest in mathematics in the classroom, and hence to begin to create a flow of young people into maths teaching as a fascinating career. The logical conclusion of this approach to mathematics is, in effect, a new subject which may be called 'maths imagination meld' (MIM). It is all about using maths as a discipline to tease-out the implications of good ideas. These good ideas must of course be present in imagination, and the mathematics then operates in a framework created in imagination.

A brick wall of incomprehension

The notion that 'Mathematics', the most hierarchical of subjects, could emerge in a new mutant non-hierarchical form (MIM) is beyond the ken of many 'hierarchy people'. One has to say that they lack the imagination to visualise the benefits it would bring – from their own point of view. They are thoroughly socialised into their hierarchies and frankly recognise that they depend vitally on them for support. Peirce himself, though acknowledged by his immediate peers as the most creative US logician-philosopher of the 19th century, was virtually ignored in the USA and also by the European schools of Peano, Russell, Hilbert, etc. He lived in seclusion and died in poverty, most of his ideas being unpublished until the 1930s. Could the extended Peircean interpretation of mathematics be fundamentally too 'way out' ever to be the legitimate new paradigm school mathematics needs? No, it is just common sense. Everyone agrees that mathematics is the study of formal truths of the kind 'if p then q', where 'p' is a set of general axioms with or without a specific set of local definitions. Peirce put his finger of the motivation that drives the quest to find out about such truths: namely curiosity about the exact implications of formal ifs. Applicable mathematicians, too, acknowledge that some applications of maths are 'projective' in the sense that they look into the predictable implications of proposed gadgets and set-ups. One can hold the focus of applications onto immediate 'practical problems' ('I am stuck and I need an answer'), or onto long term projects like NASA's trajectories for sending vehicles to the Moon, or onto various intermediate points. In other words, there is no barrier preventing the focus in the classroom from being pitched onto the kind of hypotheses that interest children. So what is the factor which has allowed both Peirce's original thinking and the extended Peircean philosophy of the 1970s to be sidelined for so long? Probably the main factor has been the inner insecurity of the culture of higher maths which set in after Russell's Paradox in 1901 and the subsequent cave-in which resulted in the adoption of fudged so-called 'foundations' for mathematics (Zermelo-Fraenkel and their successors). Russell gave these fudged foundations his 'blessing', when he adopted four unobvious axioms in Principia Mathematica. For over 100 years this has bred among subject leaders an obsession with rigour, with scholastic attention to minutiae, with a deeply instilled horror of mathematical intuition and imagination. The computer industry spotted as early as the 1950s that mathematics was a 'no hope' culture and that they must distance their machines as far as possible from it. In the 1960s the arid 'platonic' scholasticism favoured by the pure maths hierarchy was roundly attacked by the Hungarian philosopher Imre Lakatos, but he died young, and the academic movement he led withered for lack of leadership. In 1980 Morris Kline published *Mathematics, the Uncertain Science*. It catalogued the paradigm crisis in mathematics in a very thorough, clear-headed way. The official wisdom embodied confusions and paradoxes at every turn. (E.g. that there is an infinity of rational numbers between any two given real numbers.) Most higher mathematicians seemed to react with weary resignation: they assumed without question that nothing could be done about the situation: they accepted Russell's word that a fudge of some sort was inescapable.

New thinking about the basis of maths

Today a few higher mathematicians are waking up to the realisation that mathematics can be placed on a new kind of 21st century naturalistic ordinary-language 'foundation', and that the paradoxes need not be the great disaster they were formerly supposed to be. (See my monograph 'Some Varieties of Superparadox', MAG 1993.) If so, the road towards MIM as the secure future of school mathematics accepted by the maths hierarchy will eventually open up. However, we no longer need the prior approval of the maths hierarchy for changes in school mathematics. They were never happy about the Cockcroft revolution of 1982, and as a result they virtually walked away from the game. The gradual advance of computerised mathematics during the period 1960-2000 has left the pure maths hierarchy, in effect, stranded on a reef, with little public support for their now visibly specialist, pedantic culture. When Baroness Blackstone said she 'did not want any whinging from the mathematicians' (about their subject's declining numbers) she guessed she had public opinion on her side.

Dehumanisation in maths

An historic moment occurred in the 1980s. At this moment the total amount of serious adult mathematics done by machine began to exceed that done by human manipulation (paper-and-pencil + mental). This marks a profound change in the way we conceptualise maths. I think the public has become aware of this de-humanisation of maths, and that they now, mostly unconsciously, regard maths as being something more suited to machines than the human brain. In effect maths has succumbed to the same kind of change as double de-clutching gears, recording visual scenes and pumping water - all things now routinely regarded as jobs for machines. The result is grim: a sense of maths as an artificial chore now settles on many unhappy classrooms. It is simply a reflection of this historic change. The way forward is clear: away from a machine-like attitude to maths, towards a new vision of maths as an augmentation of the power of the human imagination.

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Who Is Teaching Secondary Mathematics?

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Abstract

As a part of a study into the potential for recruitment of science and mathematics undergraduates into teaching funded by the Standing Conference on Studies in Education, the School of Education is researching the expertise and deployment of mathematics teachers in secondary schools.

The last major study in this area was done for the Cockcroft Report. Whilst the current study is nowhere near as large or as detailed, the reported data comes from responses to two questionnaires sent to a random sample of 500 secondary schools, one for the head of mathematics and a second questionnaire for distribution to other members of the mathematics department. The questionnaires were sent out to schools in the middle of the summer term 2001.

This paper presents statistical data based upon these returns and some qualitative data based upon the questionnaires, to comment upon the current difficulties.

Background and introduction

The author and two colleagues, Dr. Jim Donnelly and Professor Edgar Jenkins, all of the Centre for Studies in Science and Mathematics Education at the University of Leeds, have obtained funding from the Standing Conference on Studies in Education (SCSE) to research the views of undergraduates in science and mathematics based disciplines towards teaching as a career. As a part of this research questionnaires were sent to a random sample of 500 schools in England and Wales in order to ascertain some measure of the impact of the shortage of a mathematics teachers.

Six questionnaires were sent to each school in the sample. One was coloured pink and aimed at the head of the mathematics department. Five green ones were also enclosed for distribution to members of the department. The fronts of both questionnaires were the same and asked for information on gender, age, qualifications, the level respondents regarded themselves qualified to teach to, the spread of teaching across the age range and support or training needs. The reverse of the green form was blank and respondents were encouraged to include further comments. The reverse of the pink form asked the heads of departments to:

- state how many people taught mathematics as a time-tabled subject,

- estimate the proportion of mathematics lessons taught at each Key Stage by qualified and unqualified staff,
- estimate the proportion of mathematics lessons taught at each Key Stage by full and part time teachers of mathematics,
- provide written comments on these issues and their impact, if any, on the quality of mathematics teaching in their schools.

This paper reports upon a partial and very preliminary analysis of the questionnaire for heads of departments. The questionnaire was sent out in mid-June 2001 and the most recent returns are not included in the results presented below.

Basic information

The questionnaire was sent to a random sample of 500 schools in England and Wales. To date over 170 schools have replied and more than 500 individual teachers of which approximately 140 are heads of department.

The data below reports upon responses from those heads of department from schools with the age ranges 11-18, 11-16 and 13-18, and includes state and independent schools. Some middle schools and preparatory schools included in the sample also responded but these are excluded from this analysis.

The analysis of the data

Gender distribution

Gender Distribution, Heads of Mathematics Departments

	Female	Male	Undeclared	Total Surveyed
State	53 (52%)	40 (39%)	9 (9%)	102
Independent	13 (54%)	10 (42%)	1 (4%)	24
Total	66 (52%)	50 (40%)	10 (8%)	126

The trend would appear to be towards a head of department teaching force that is more female than male. This trend is supported by anecdote. In one LEA, in 1987 there was the only one female head of department; now over half the heads of department are female. It will be interesting to see if the relative proportions for heads of department reflect the gender distribution across the sample as a whole.

Age distribution

Age Distribution, Heads of Mathematics Departments

	20-29	30-39	40-49	50-59	60+	Total
State	2 (2%)	24 (24%)	43 (42%)	32 (31%)	1 (1%)	102
Independent	1 (4%)	3 (13%)	4 (17%)	15 (63%)	1 (4%)	24
Total	3 (2%)	27 (21%)	47 (37%)	47 (37%)	2 (2%)	126

These figures reflect those of John Howson for the whole of the teaching profession published in the Times Educational Supplement of 7 September 2001. It is worthy of note that there is almost a complete absence of those aged 60 and over.

Interestingly, small though the numbers are, the independent sector shows an age profile which represents an older and perhaps therefore more experienced section of the profession.

Who is doing the teaching?

The Cockcroft Committee did the last major survey into the teaching of mathematics; their Report provides the following data for comprehensive schools in England and Wales: (Table 19, page 259)

Deployment of 'unsuitably' qualified teachers (Percentages)

% of mathematics curriculum taught by 'unsuitably' qualified teachers in:[1]	**11/12-18**	**11/12-16**	**All**
Year 1	48	46	47
Year 2	45	47	46
Year 3	39	42	40
Year 4	37	40	38
Year 5	36	40	37

Source: DES 1977 Survey of Secondary School Staffing

[1] 'unsuitably' covers the aggregate of teaching by teachers with 'weak' and 'nil' qualifications.

There is insufficient space to give the definitions of 'weak' and 'nil' qualifications used by the Cockcroft Report, but the highest qualification in the category of 'weak' is, 'Teachers holding the Certificate in Education having followed a secondary course with mathematics as a second or subsidiary subject providing their first or main subject was related.' The two other categories are 'Good' and 'Acceptable'. All categories are defined in terms of mathematics degrees or other mathematics qualifications. It is difficult to know where an engineering degree, for example, might fit into the DES/Cockcroft categories.

Teaching by qualified teachers

Our definition of 'qualified' was:

> [1] A degree, or other qualification in mathematics, above A-level, and/or a teaching qualification at an appropriate level, with mathematics as a major component.

and this was given on the questionnaire.

The question posed to the heads of department was:

> Please tell us the proportion of mathematics lessons given by qualified [1] and unqualified teachers in your school, expressing the figure in each case as the percentage of time-tabled lessons taught at each level (i.e. horizontal rows should add to 1000: both figures are asked for in each row only so as to make this point clear).

	Percentage taught by:	
	Teachers with an appropriate qualification in mathematics teaching [1]	Teachers without an appropriate qualification in mathematics teaching
KS3		
KS4		
A-level (if applicable)		

The results derived from this question are shown in the three tables below. Again the figures in brackets are percentages of the totals in the end columns.

What the tables tell us is that, for instance looking at the Key Stage 3 (KS 3) table, in 44 state schools all the teaching at KS 3 is done by qualified staff, whereas in 21 schools 90% of KS 3 teaching is done by qualified staff, 10% unqualified staff, and so on.

Qualified teaching, Key Stage 3

	All	90	80	70	60	50	Number surveyed
State	44 (43)	21	23	7	7	0	102
Independent	17 (74)	2	2	1	0	1	23
Total	61 (49)	23	25	8	7	1	125

Qualified teaching, Key Stage 4

	All	90	80	70	60	50	Number surveyed
State	52 (51)	22	21	3	2	1	101
Independent	23 (100)						23
Total	75 (60)	22	21	3	2	1	124

Qualified teaching, A-level

	All	90	Number surveyed
State	56	1	57
Independent	22		22
Total	78	1	79

The tables suggest an obvious comparison between the state and the independent sector in terms of the availability of qualified staff. Also obvious are the comparisons between the key stages. Like the Cockcroft data, the situation improves with age and, in this case, ability. However, detailed comparisons should be made with the Cockcroft data only with great caution. The definitions of the term 'qualified' are similar and might be judged comparable. However, it was not the purpose of the research to replicate the Cockcroft data in any way, and so, whether the situation is better or worse than it was in 1977 and by how much, are not questions that can be answered from the data above.

Heads of department were asked to comment about the impact of these figures, and those below concerning the use of part time teachers, upon the quality of mathematics teaching in their school. The following points arose:

> The data is sensitive to apparently small changes in one school. Thus one 11 –16 school with five full time staff in the department indicated that next year they will be losing a full-time, fully qualified teacher and have been unable to employ an equivalent replacement. The amount of qualified teaching at KS 3 will fall, they estimate, from 100% to two-thirds, and at KS 4 from 100% to 80%.
>
> Many heads of department were very grateful to have fully qualified staff and dreaded losing them. Several reported dire shortages of adequate supply teaching and the apparently fortuitous replacement of staff who had left. In the case of the former, several reported that just getting a body, irrespective of qualification, in front of the classes was almost impossible. The situation was particularly acute when a department was faced with long term staff illness. Illustrating the latter, one school reported advertising for a second in department, it received two applications, only one of which was suitable on paper and that applicant was offered the job at interview. Another school advertised a post suitable for an NQT, had no applicants, but received an ITT student from their local HEI who turned out to be reasonably good, was offered and accepted the job.
>
> There were several comments raising the age long argument about qualifications as opposed to ability to teach, often through polarising the argument around the mathematician unable to communicate and the non-mathematician very able in communication.
>
> There were many indications that things would be worse next year, or in the near future, through retirements, promotions and colleagues leaving the profession or moving between sectors. There have been several anecdotes that have emerged about staff leaving the state sector to move into the independent sector. Thus in Leeds the head of science of a well-known secondary school has resigned his post and gone to teach science in the independent sector as an ordinary teacher. Within the data, a head of department reports this happening to a member of his staff. The event is confirmed by the return of a questionnaire by the member of staff in question.

Teaching by part-time teachers

The definition of a part-time teacher used was:

> Three-quarters or less of a full teaching timetable, **including** those who spend the rest of their time working in school, but not teaching mathematics.

Thus the definition included deputy headteachers and the like as well as those employed as part time staff.

The question asked of the heads of department was precisely similar to that asked about qualified staff. The tables below show the analysis of this question and provide information precisely similar to that for qualified staff.

Full-time teaching, Key Stage 3

	All	90	80	70	60	50	40	30	Number surveyed
State	25 (25)	24	20	19	9	3	2		101
Independent	5 (23)	1	5	5	2	2	1	1	23
Total	30 (24)	25	25	25	24	21	5	3	124

Full-time teaching, Key Stage 4

	All	90	80	70	60	50	40	30	Number surveyed
State	29 (29)	18	27	9	13	1	3	1	101
Independent	6 (29)	5	2	1	3	2	1	1	21
Total	35 (29)	332	9	10	16	3	4	1	122

Full-time teaching, A-level

	All	90	80	70	60	50	40	30	Number surveyed
State	39 (70)	4	3	5	2	2	0	1	56
Independent	11 (52)	1	5	1	0	2	0	1	21
Total	50 (65)	5	8	6	2	4	0	2	77

The independent sector appears to use far more part-time staff than the state sector at A-level, but this is all qualified staff. In the state sector returns, the estimated figures for full-time teaching and qualified teaching are sometimes identical, a possible inference being that the unqualified staff are also part-time staff. It is also clear that in many cases the part-time staff is well qualified being, perhaps, a previous head of department who is now a year head or deputy headteacher.

However, part-time staffing, well qualified or not, has some clear disadvantages according to the comments made by some of the responding heads of department. Areas of reported difficulty include:

split classes,

monitoring pupil progress,
having and maintaining clear departmental policies about teaching and learning,
the general management of the department.
These areas give rise to many of the same issues as the use of unqualified staff.

Conclusions

The older and brighter the pupils, the better they fare terms of the use of qualified or full-time staff. The reasons are not hard to find, examinations, SATs, GCSE and A-levels, and the resulting league tables, provide the motivation for putting the best team on where the school feels it matters most.

However, several heads of department do comment upon the potential effect of poorly qualified or part-time staff upon young, bright, mathematically talented pupils. This is an effect that cannot be measured. Once lost to mathematics, such pupils are likely to be lost forever.

The figures show a bad situation, but is it going to get worse?

PGCE recruitment onto mathematics courses appears to be up on last year. The final figures are not yet known, but GTTR has regularly reported a rise in applications of around 20%. Other routes such as the Graduate and Registered Teacher Programmes and Modular PGCE courses are increasing their contribution, though the extent to which they contribute to mathematics is not yet known.

However, the drop out rate from within PGCE courses is rising. At Leeds we know from research carried out by Chambers and Roper (2000) on why students withdraw from PGCE courses, that our own drop out rate has risen from around 5% to around 10% of the intake. Further, research carried out by Chambers, Cole and Roper (2001) for the Teacher Training Agency in the same area, but based upon eight providers across England, shows an average drop out rate in the range 15-20%.

Once in the profession, our product is not staying. Her Majesty's Chief Inspector, Mike Tomlinson, has reported that 40% of new entrants to the profession leave within three years of entry. This is a heavy wastage rate. Combined with the age profile of the current cohort, the future is indeed bleak, not only for the availability of mathematics teachers, but teachers of all subjects.

As noted at the beginning, for this piece of research the data has not yet been completely analysed and neither have the returns from the main part of the research on science and mathematics based undergraduates' views about teaching as a career. However, without wishing to pre-judge this research, two strong themes are beginning to emerge, pay and image, with the latter appearing the stronger of the two. If this proves to be so, there may be no quick fix available through raising pay without considerable efforts being made to improve working conditions, image and status.

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School Maths Teaching: the Thinking Person's Nightmare?

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Abstract

A recent review of research (Spear, Gould and Lee 2000) into motivating and demotivating factors for teachers found that in order to experience high job satisfaction, teachers need an intellectual challenge, autonomy, to feel they are benefiting society, to enjoy good relations with their colleagues and to spend a sufficient proportion of their time working with children. This paper offers a personal account which endorses in particular the first two of these factors.

Many reasons have been put forward to explain the deluge of schoolteachers leaving and the slow trickle of new recruits entering. It is likely that the factors which gain media coverage, 'low' pay, long hours, disruptive pupils, stress, etc. all contribute to the decisions people make about the profession. I would like to suggest a different perspective based on my own experience. A recent review of research (Spear, Gould and Lee 2000) into motivating and demotivating factors found that whilst teachers suggested reasons like the ones cited above to explain the demotivation of the profession in general, they put forward other explanations for their own dissatisfaction. The review used a model to analyse the results of a large number of studies and found:

> The main conclusions … are that in order to experience high job satisfaction, teachers need an intellectual challenge, their autonomy, to feel they are benefiting society, to enjoy good relations with their colleagues and to spend a sufficient proportion of their time working with children.
>
> (Spear, Gould and Lee 2000 op.cit)

I would agree wholeheartedly with the conclusions above: this paper offers a personal account which endorses in particular the first two factors.

I trained to teach mathematics on a two year Postgraduate Certificate of Education (PGCE). Had I not experienced the first year of the course I doubt whether I would have entered the classroom at all. During that first year I came to understand both mathematics and teaching in a wholly new light. Towards the end of the training I wrote a personal enquiry for one of my education units:

> It is impossible to exaggerate the revolution that occurred in my thinking and outlook as the result of the teaching I received in the maths education department. My understanding of maths broadened and deepened … It is very exciting to discover a whole new world of learning… The way we were taught, the resources we used, and the reading/reflection we were encouraged to do all stimulated thought and I now see how many questions were planted during the first year which I have never stopped considering. Spending time in schools confirmed how much I wanted to teach… It also opened my eyes to a whole range of issues and gave me some solid experiences around which to develop my thoughts about teaching. … I feel less and less certain of where I stand on a whole range of educational issues, everything is much more complicated… In the end the main benefit of the PGCE has been to get me thinking/reflecting… I find it sad … that so many teachers are despondent and cynical about their job. It is very disheartening to be asked by so many teachers why I can't find something better to do with my life! [1993]

I am not alone in my response. In an enquiry into trainee teachers' perceptions of citizenship, trainees following the same two-year route made the following comments:

> The only thing I thought (about citizenship in the curriculum) is just how we were taught last year generally. It was quite difficult to start with. I was having to think … I wasn't just told the answers. I had to go into things out. So it created a skill to be able to go away and find things out for yourself …
>
> I liked it. I could see it was a better way of learning mathematics right from the beginning of the course when we first started working like that. In lectures straight away you were talking about mathematics.
>
> (Povey and Angier 2001)

Having qualified, I then worked for eight years in three different comprehensives in South Yorkshire. For some of the time I had a part-time contract and I took on some additional teaching of maths back in the university where I trained. This September I took up a full time post in the Maths Education Centre at the university.

Working in school feels like being squashed into a very small dark place where there is no room to manoeuvre either physically, or mentally. Coming into the university my first reaction was to be astonished at the temporal luxury. I can 'wander' during the day, to the toilet, to the coffee room, to the library (am I really being paid to read books?). I can make decisions about the order in which I do tasks. I can choose to work at home for part of the day etc. I doubt that I am unusual in the ranks of those who have left teaching in feeling a sense of freedom. What is much more significant for me though is the new-found intellectual space and the opportunity to use skills which were redundant in my school teaching job.

At the university I am unit leader for one of the courses I am teaching. I have the definitive course document laid down by the university, a file of past lecturers' resources, students' feedback and a set of colleagues many of whom have taught this or similar units in the past. It is then down to me! I can structure my teaching as I wish. I am to be guided by the indicative content but not bound by it. When I asked my mentor who I should consult if I wanted to reorganise the assessment tasks he explained that I was free to decide for myself. This level of trust and responsibility is astonishing and lovely. The contrast to school with its strictly imposed and monitored curriculum and fierce regime of testing could not be starker. Dave Coulby (2000) describes eleven policies through which 'surveillance, discipline and control' of teachers are to be achieved in schools in England and Wales. I was always aware in school that the teachers who were the most disgruntled were those who had entered the profession some time before the National Curriculum and testing were introduced. As Fielker (2001) comments: 'It is a salutary thought that anyone who has been teaching less than 13 years has no idea of the freedoms we used to have'. There is evidence that the National Curriculum and market-led education system have led to a significant shift in classroom practice (Sukhnandan and Lee 1998). Teachers reminisced about developing curriculum initiatives, time away from lessons to undertake projects with other schools, etc. and I appreciate now how appalling it must have been to have begun working that way only to have all those opportunities taken away. No wonder so many experienced and talented teachers have chosen to leave.

In making the decisions about my unit I have to consider other lecturers who have been or are or will be teaching the same group. In a context where we actively make links within the subject and try to confound the idea that all learning can be reduced to tiny bite-sized morsels it is likely that our indicative content will have fuzzy edges where our units overlap. This in turn leads to discussion with my colleagues – discussion about mathematics teaching and learning. In my experience this is a rare treat in schools! Even if the teachers had the time or the opportunities the structure of the curriculum into hierarchical levels and the division of the children into sets creates a false illusion of separateness.

I am in no doubt that the reason I enjoyed school teaching was because I had been 'set up' on my PGCE to see it as an intriguing endeavour and to recognise a cornucopia of worthwhile educational outcomes to strive for in my classroom. I was also very fortunate in maintaining links with my training university and finding opportunities to be involved in research. All of which kept me reading, kept me asking questions especially of myself and essentially kept me interested in what I was doing.

At my last school I taught next door to a young teacher. She came to the school as a Newly Qualified Teacher and when I left she had completed her second year. In all the schools I have been in, I would be hard pressed to think of a more highly skilled teacher. She was undoubtedly exceptional. In a conversation, she mentioned that she was considering leaving teaching because she was becoming bored and felt that she was not learning anything. I have thought a great deal about her since that conversation and my reflections upon moving from school to university have had her surprising comment as a backdrop.

To be a thinking teacher in today's schools is a struggle and, I suggest, that without support from likeminded colleagues or from outside agencies, it is almost impossible. Everything about the organisation of school mitigates against asking questions, discussing with colleagues and experimenting within the classroom. School teachers have scarcely any time to eat their dinner let alone engage in collaborative projects; and those who have won time through promotion often lose touch with, and interest in, the classroom.

The young teacher next door to me was unusual in that it took her so little time to get on top of the demands of classroom teaching. She was never scurrying for a lost resource or having management difficulties. And she was not a dull or unimaginative teacher: her lessons were full of activity and variety. But it seems to me that she lacked a sense of what the whole project was about. She had been trained on a one year PGCE at a university which did not offer longer routes and she did not seem to have had an opportunity to engage with wider issues around education and learning in any meaningful way. I think it is quite common for one-year PGCE students to feel that education studies is all a bit distant and academic, because they are trying to live through an exhausting and demanding year of teaching practice. A few years on, though, when, like my colleague, they feel confident enough to take children outside to work, or are happy to allow groups to use the multi-link with out fearing it will end up out of the window, what challenge is left for them? What should they then start to think about? The answer within the school system is raising achievement in terms of exam results. It is a small and ugly answer.

I was fortunate to have had a training which inspired me, gave me a deep sense of the possibilities and challenges of teaching and which I could draw on to sustain me as I battled to maintain my beliefs within a system I was always at odds with. Teachers who understand the job only in terms of the competencies list of their initial training and the league-table results of their school will after a few years, I suspect, find the job intensely boring and repetitive. If they have a genuine interest in the well-being of young people, as do the vast majority of beginning teachers, then they may well decide they want to distance themselves from the undemocratic, exam-oriented, and limiting institutions that schools have become. No wonder so many new teachers leave within the first four years.

There are, of course opportunities for teachers to engage with the issues around maths education. There are subject associations such as the Association for the Teaching of Mathematics and the Mathematics Association, and there are the accredited courses offered by Higher Education Institutions. My contention, though, is that these initiatives are outside the current culture pertaining in schools. In my last year of teaching I received a Best Practise Research Scholarship from the Department for Education and Skills (DFES 2001). I used some of the money to attend a (Saturday!)

conference in Bristol where an inspiring group of teachers had collaborated with the University of Bristol on a project to explore ways of working with Y7 pupils. I found it very difficult to engage my department in my BPRS and the only interest shown by the senior managers was a comment by the manager in charge of staff development who said one day, in passing, 'I'd like to talk to you about your research, Corinne, but I don't have time'. The school had a very strong policy of minimising disruption to teaching and I was only able to undertake the project at all by agreeing it would not interfere with my teaching. For instance, I could not bring in supply staff to cover any of my lessons, but only to cover non-teaching tasks such as exam supervision.

The space for continuing professional development in mathematics departments has been dominated by statutory numeracy 'training' which consists of centrally-planned sessions delivered in a highly didactic manner. The premise is that: 'Now we know what to do, it's in the Strategy, and there is no need for any discussion'. The idea that exactly the same solutions are suitable for every single mathematics classroom in the country is astonishing and of course deeply ironical in the light of government complaints that schools are wrongly organised around a 'one size fits all' mentality. There seems to be an underlying message that the government through its quangos has done the necessary research and the teachers are the technicians who will put the results into practice. English teachers are not alone in struggling against this 'didactic superego' (Hefendehl-Hebeker,1998)

Given all the features that currently detract from the profession, teachers need a strong reason to stay in the classroom I suggest that active intellectual engagement with the process of teaching and learning mathematics is a powerful reason. An HMI report 'Girls Learning Mathematics' (1989) closes with the modest admission:

> The HMI working together on this exercise found that focussing on girls' attainment led them into interesting discussions about the nature of mathematics and mathematical learning for all pupils. It is hoped that readers of this report will find it provides the stimulus for a similar analysis of their own approaches to mathematical education.

There is, of course, a vicious circle. The fewer maths teachers there are the less the likelihood that they will be able to take time away from the classroom to read, think and discuss. The rarer will be the teachers who sit and write:

> 'I am a full time mathematics teacher with all the time-consuming responsibilities and duties this implies. I began this research in response to problems I perceived occurring in my classroom' (Lee 1998)

If a teacher is not able to bring her intellectual skills to bear on her work, it is a tremendous loss to the profession, her immediate colleagues, and the children she teaches.

To have the space to question and explore presupposes a sense of being trusted and a degree of autonomy. Teachers value this latter characteristic highly (Spear, Gould and Lee, 2000) and the more they feel shut into a system which makes exhausting demands and monitors their every move the more likely they are to quit altogether. Schools are becoming decreasingly spacious. McLaughlin (2000) describes a joint project and characterises three discourses amongst the participants: the academic community and funding body talked of 'validity and rigour'; the head teachers talked of 'management and accountability'; and the classroom teachers talked of 'learning and caring'. It is very difficult for teachers to engage with the bureaucratic discourse precisely because it feels like another language from an unrecognisable planet!

I cannot imagine a more difficult or more interesting job than school teaching. I did not resign because I felt too miserable or stressed to continue: indeed I was about to interviewed for a head of department post. But I was offered a job in higher education and I chose the opportunity to take a breather and think about what goes on in schools, and in my classroom in particular. I find the whole process intriguing. What exactly is happening in those 50 minute slots? Who is learning what and how? Why does the ethos of the school, and the character of the management, have such a huge impact upon the way I operate within my classroom? Why am I still always so surprised when my lessons demonstrate that my beliefs and values do make sense even though they run utterly counter to the prescribed wisdom? What really does change the way teachers work with students? – because it certainly is not new ring-binders full of advice or dull Government Issue training sessions. What was I getting right when my low attaining, minimal self esteem, year nine group were set alight by exactly the same mathematical challenge that another teacher was pursuing with the top set next door?

I could go on because for me the questions are endless and I love exploring them. That is what sustained my interest in the job and encouraged me to experiment, reflect, and modify in a never ending cycle of micro-action research.

New recruits coming into the profession might well see the job differently and assume that it is all about classroom control and attainment value-added scores. They might also be forgiven for conceptualising their job as a battle fought against difficult young people with unhelpful parents on a battle field so uneven and unpredictable due to the forces of inspection and curriculum change as to render any sensible planning of strategy pointless.

Most of the people I speak to tell me that I will never 'go back in' and I can understand why people find it hard to reverse the move – even with a £4000 sweetener from the government. I hope I do return because there is so much more I would like to find out.

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Mathematics Teacher Shortages: Some Suggested Actions

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Teaching in crisis

Over the years we have had many crises in teacher supply but the scale of the current one *seems* unprecedented, not only in magnitude but also in the range of subjects affected. The problem is no longer restricted to the recruitment and retention of sufficient *numbers* of teachers for *mathematics* (which has been of concern for an number of years), but also for science, design and technology, modern foreign languages and, even in primary schools, recruitment is becoming a major problem in many areas of the country.

Recently, the Chief Inspector, Mike Tomlinson, gave publicity to the crisis, stating that about 40% of teachers leave the profession within 3 years. Even allowing for a significant number leaving the profession to have a family, this is an incredibly high figure! The government's dismissive response in saying that the figure of 40% has remained unchanged over a number of years, does nothing to address the problem; if we cannot keep 40% of teachers in post for more than 3 years, surely it is time to find out why and what can be done to change this pattern. If we could solve this problem, we would have plenty of teachers.

The government points to the successes of its recruitment policies, which over the past few years have included,

- salaries for PGCE students
- 'golden hello' lump sums for teachers in shortage subjects
- fast-track routes for well-qualified teachers
- training on the job through the GTR programme
- inducements for those returning to teaching

and which have resulted in more teachers in schools than ever before. What they neglect to say, though, is that, with the boom in the birth rate of the 1980s, there are also significantly more pupils in schools than ever before!

There is also another aspect to the recruitment and retention problem in that some student teachers, having qualified, do not go into teaching at all. Although anecdotal, it is worth looking at some case studies. Here at Exeter, for secondary mathematics teaching, we have had both a 4-year undergraduate course (leading to B Sc in Mathematics Teaching with QTS), and the usual 1-year PGCE. Our undergraduate class of 1997, consisting of 15 students, graduated this year. In fact, only 11 graduated as we lost 2 en route (one decided to do a mathematics degree, the other dropped out) and 2 failed some of their final papers (although it has to be said that neither intended to teach). Of the 13 who took finals, all had achieved QTS through their regular teaching periods in schools, yet as of today (September 2001) only 2 are actually teaching mathematics in schools (in fact, 3 are globe-trotting, one of whom is likely to teach when he returns). As one of the tutors to these students, I can say that most, if not all, would have made competent and some even inspirational teachers, yet at best only 20% of them will be teaching in schools at least in the near future.

Asking them why they were not going into teaching in schools brought a number of interesting responses, including,

- I really enjoyed the 4-year course but conditions of service in schools were so poor.
- We want to teach, but that seems almost the last thing you can do now in schools, and even when you do teach, the government dictates what you teach and haw you teach it.
- Teaching is no longer a profession; it's as if we are not allowed to think for ourselves.
- I want a job where I can be creative and where pupils want to learn.
- I would only ever contemplate teaching in the independent sector after experiencing both on my teaching practices.

What they were all agreed on was that it was not the pay that was the crucial factor in their decision not to enter the teaching profession, but the conditions of service. This was not helped by many teachers in school advising them to find gainful employment outside teaching.

It was a similar story for our PGCE group, although not quite as disastrous. Of the 26 who started last year, 3 left during the first term – just one visit to a school was enough for them to realise that this was not for them (they had clearly been attracted by the 'golden hellos' and positive advertising), and we lost a few more during the two terms of teaching practice with the result that about 60% of the original number actually entered teaching in September this year.

You might be tempted to criticise our training courses, or indeed the partner schools in which their teaching practice takes place, but this is far too simplistic. Teaching is increasingly being perceived as a service industry rather than a profession. The teacher delivers the National Curriculum, meets targets, completes vast amounts of paperwork (in the name of 'planning'), and has little chance to show and use their individual and maybe distinct talents for teaching. Also, in the state sector, but not in the independent sector, the constant complaint from our student teachers is that in too many classes there are pupils intent on wrecking the working environment of the whole class, causing disruption at the least possible provocation.

In summary, the teacher crisis is not due to a crisis in supply, but is symptomatic of a much deeper crisis in schools in which teachers are no longer treated as professionals with a professional job to do, and pupils in many cases seem unwilling or unable to learn. Whilst we can debate the current difficulties of finding people to teach mathematics, this is not the real problem but just a manifestation of the deep malaise that is affecting many schools and their teachers today. Of course, we have been experiencing economic expansion with a very low unemployment rate, and, if as seems likely, we are heading for a recession, recruitment will pick up. Even then we need to take care in our recruitment policy. What is really needed for the longer term prosperity and well-being of the teaching profession are entrants of the highest quality in their chosen subjects.

Mathematics teaching

Over the years, there have been distinct changes in the entry patterns for the PGCE courses at Exeter. Twenty years ago, the majority of entrants would have enrolled immediately after completing a mathematics degree, with some possibly having taken a maths related degree such as Engineering, and a few having spent one or more years doing something else after graduating. Now, we are surprised if we have even a few students straight from a mathematics degree. The majority of students have been in employment for some time, with the average age significantly higher than in previous years.

Of course, this is not necessarily a negative situation: these students bring to teaching a vast array of experiences that the new graduate cannot have. The danger lies in the possibility that some of these students come into teaching having become bored with their previous job or having been made redundant or just wanting a change; the recent financial inducements do understandably encourage people of this type. My concern is that these are not 'dedicated' teachers who have always had teaching as their goal. The previous TTA chief executive, Anthea Millet, stated the view that "teachers are not born, but trained" whereas I think the reverse is more likely to be true, in that people are *born* to be teachers, but that, hopefully, training improves their effectiveness.

These 'born teachers' are very talented people who will also be attracted to other professions which are characterised by

- providing an outlet for creative thinking
- treating individuals as professionals
- trusting people to take responsibility
- providing a challenge to professional expertise
- being respected in the community.

Unfortunately (mathematics) teaching as a profession seems to fall down on most, if not all, of these points; creative thinking appears to be deadened by the myriad of instructions from government, including

- National Numeracy Strategy
- catch-up material
- target setting
- short, medium and long term planning.

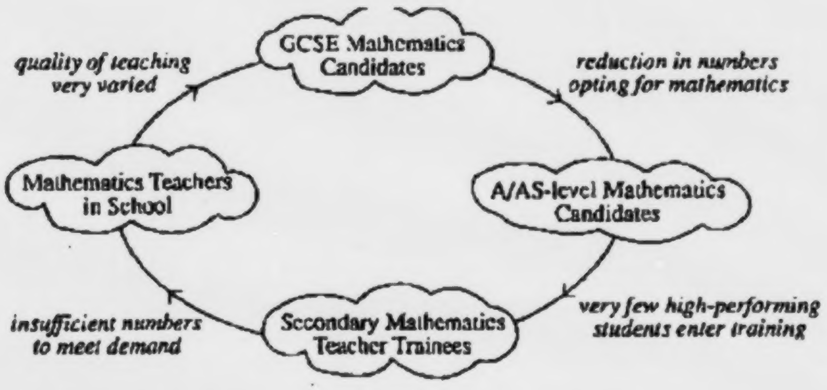
Far from being treated as a professional, as a teacher you have to be inspected regularly (often by people who are incapable of actually doing the job of teaching), your effectiveness is assessed by league tables (in which like is not compared with like), you have little or no chance to teach mathematics at the cutting edge of its development, and respect from the community (as it is reflected in media coverage) is difficult to find. On top of all this, it was deemed a good idea to examine the student teacher skills of numeracy, literacy and ICT in tests to be taken during the training period. This, despite the fact that the student has achieved a Grade C GCSE in English, and possibly a degree in a mathematics-related subject. It is this lack of trust that deters the potentially inspiring teacher from even starting training and for many potential mathematics teachers, the literacy test is a really negative factor in trying to encourage them into teaching.

So mathematics teaching, despite (or because of) the government's push to raise attainment, is in crisis. And the crisis is deepening. We continue *not* to attract the high fliers into teaching, but often scrape the barrel to fill our teacher training places. In this way we are attracting people into the profession who are not creative, cannot think for themselves and will not make inspirational teachers. Many of these are content to toil on with the dreary work of form filling, because they are not in the profession for the right reasons – they are not born teachers, but welcome direction and instruction at every turn to support them in their role.

What is the result? Yet more dull and boring mathematics teaching, which will not inspire the next generation into teaching (or even to continue studying mathematics).

In short, the situation will get worse, with more and more supply cover needed for schools to cope, and ever fewer mathematically well-qualified teachers drafted into teaching mathematics. (I do recognise that some of these people do a super job, but only some!)

It is this background that should concern not only the government but everyone involved in education, and in mathematics education in particular. We somehow have to break this cycle. Despite the recent AS/A2 reforms at A-level will inevitably lead to still fewer students taking a full A-level in mathematics.


GCSE Mathematics Candidates
reduction in numbers opting for mathematics
A/AS-level Mathematics Candidates
very few high-performing students enter training
Secondary Mathematics Teacher Trainees
insufficient numbers to meet demand
Mathematics Teachers in School
quality of teaching very varied

The suggestions that follow are based on our experiences at the Centre for Innovation in Mathematics Teaching at Exeter University, working during the past 5 years with about 75 project schools in our Mathematics Enhancement Programme (MEP). These schools are typical of secondary schools across the country; they include independent schools, grant maintained and normal L.E.A. comprehensive schools. As with the rest of the country, recruitment this year has been difficult with vacancies for mathematics teachers filled by a variety of means, including

- non-specialist teachers
- long term supply cover
- non-qualified staff, including students on GTR programmes
- returners to the profession
- teachers from overseas

but despite this, there are still schools with only one maths specialist teacher.

Suggestions for action

The following ideas are based either on current practice or on an expanded version of current practice.

Student volunteers

In two of our project schools, we have had some experience of using volunteers. These happen to be young graduate employees of a major industrial firm, and they do not teach, but help the class teachers on a regular basis (usually once a week for one hour). This has proved helpful both in giving extra help to low attainers, and in giving challenging problems to faster pupils. Whilst, with our current scheme, it is unlikely that any of the volunteers will actually become teachers, the scheme could be extended to include

- maths and science undergraduates
- helping for 4 days or 1 day a week
- perhaps actually teaching (with training from the local HE Education Department).

In return, the government could waive some (or all) of the current fees, and there might be a spinoff here in that the experience could encourage more of the talented students, of the type we need, into teaching mathematics. In many of the areas with chronic recruitment difficulties there are neighbouring H.E. institutions with potentially hundreds of possible undergraduate volunteers.

Teacher Conversion

Whilst the TTA is already investing in such a programme in a number of H.E. institutions, the scheme could become a more regular and automatic procedure, by providing, for example, a web-based training pack for teachers of other subjects (for example, PE), which would include

- key information on the mathematics National Curriculum
- diagnostic tests to help understanding of key topics and concepts
- detailed lesson plans for Y7 and Y8 to help in induction
- video clips of best practice

and a nationally based qualification, which would recognise and quantify this conversion. With a shortage of teachers in many subjects, this might be of limited value, but the government needs to acknowledge that mathematics is such a key subject that, for the sake of the future prosperity of the country, it should be given special consideration.

Returners

This is similar to teacher conversion, and indeed the same sort of provision and qualification is needed. If only a fraction of the people in the country qualified to teach mathematics returned to the classroom, the problems would be solved. It should though be noted that, by itself, this scheme is of limited value. There has to be a definite move to improve conditions of service if we are going to attract good teachers back into the classroom and salary is only one aspect of this problem. This is considered in more detail in the final section.

Teachers from other countries

With globalisation, this is undoubtedly one way ahead that can have a dramatic effect in a short time. There are many maths teachers in countries such as Albania and Bulgaria (and other Easter European countries), Australia, New Zealand and South Africa, China and other countries in the Far East who could solve our current crisis. Indeed, many of these teachers will have been trained to teach in a highly interactive style (as currently recommended by our government!) and could well be superior teachers to many of their colleagues in UK schools. However, there are dangers in this; for example

- teachers often have to be chosen without their teaching having been observed (we have heard of telephone or e-mail interviews!)
- sometimes their grasp of English would prove a difficulty for effective teaching (although this should improve rapidly when they are here)

and such a solution might, in the long term, cause even greater shortages of home-trained mathematics teachers. It is, though, a very tempting short-term initiative and already being used by some schools. There numbers are likely to increase in the next few years.

For these teachers, an online 'UK' training package along the lines of the suggestions above might be helpful. This could be studied before they reach the UK.

Computer aided learning

During the 1970s, the lack of qualified maths teachers in inner London was a factor in the increased use of schemes such as SMILE, in which the teacher became an administrator rather than a teacher. Whilst most commentators would not regard the self-paced individualised schemes as anything but a disaster, the concept could be more successful if it included limited whole class teaching and diagnostic software to back up lessons.

So, for example, in Years 7 and 8, pupils could have half their lessons from an effective (and inspirational) teacher, with the other half computer based. This would require really expert software that would not only test understanding of concepts, but would also recognise the main errors being made. In our own project, we have provided Year 7 support for pupils through an interactive, internet version of each lesson. This is not aimed at replacing conventional teaching but has been developed for pupils who, for example, miss a lesson or have long-term illness or need extra practice. The software, which is freely available, is on our website at www.intermep.org under Y7 of the *Mathematics Enhancement Programme*.

To replace a teacher for significant amounts of teaching time would require more sophisticated software, but it could be done if it was government sponsored (and then made freely available to all schools). It would, though, be a disaster if left in the hands of commercial firms, which are tied to making a profit, as can be seen from the many ILS (integrated learning systems) now available.

Longer term initiatives

The above suggestions for action are short-term initiatives aimed at alleviating the current crisis; they certainly will not provide a long-term solution to the problems in education. The following suggestions could form the basis of a plan to move education out of its current abyss and provide at least a foundation for the teaching profession to become one that will attract applicants of the highest quality, on a par with the professions of doctor, dentist and lawyer.

Raise entry qualifications

Instead of the fatuous computerised tests currently compulsorily taken by teacher trainees, higher grades for English and Mathematics GCSE, (e.g. grade B) or maybe AS–level qualifications as a minimum, should be a requirement. For undergraduate courses for primary teaching, we need to ask for grades A and B, and for PGCE training, we should expect an upper second or better. This might cause some initial difficulties with recruitment, but in the longer term, will indicate that this is a profession for the highest quality graduates.

Learning from other countries

We are not the only country having difficulty with recruitment but we can learn much from others which have fewer problems with their education provision. For example

(a) Most countries have a much more simplified structure in schools, with a headteacher, and with administrators to deal with the paperwork undertaken by many of our teachers. This leaves teachers free to *teach,* with the great majority of teachers remaining as teachers (the Head of Mathematics often tends to be a yearly rotating job, taken by each teacher in turn!) and the salary scale stretching further than ours. We need to dispense with all the peripheral jobs (e.g. Year Head, Senior Teacher, Timetabler) so that teaching is a profession *in itself* with teachers fairly rewarded for their professionalism without having to take on further peripheral tasks in order to gain either a fair salary or respect from others.

(b) This country seems to be almost the only one in the world for which supply cover is big business. Recently, several firms have announced inducements for schools to use them, and those running these firms have made fast (and vast) profits! However, we all know that in most cases, supply cover is a very poor substitute for real teachers. The widespread use of supply cover increased as the government expected more and more of teachers to attend courses during school time. If, as suggested above, we want teachers to be respected as professionals, they must also act in a professional manner, and be willing to attend courses outside school hours, during evening, weekends or vacation times. They should also be willing to participate in any courses that are relevant to their teaching.

(c) Another aspect that seems to dominate here but not in other countries is the widespread use of consultants and the quangos that employ them. As an extreme example, the equivalent of QCA in Vietnam (similar population) has 20 experts working for it, whereas QCA has well over 400 full-time employees and thousands of part-time consultants. Yet the decisions that are reached regarding examinations are clearly misguided and not based on rigorous research. If only *real* teachers could contribute to the policy decisions being taken, the endless mistakes that continue to be made would be a thing of the past. Not only QCA, but also TTA and DfES through their variety of initiatives (most notably the Numeracy and Literacy Strategies), employ thousands of people, producing reams of advice for schools to deal with. Whatever the (perceived) problem, there is another circular, glossy poster, website address, etc. whereas, in most cases, professional teachers are quite capable of using their own expertise, judgement and creativity to make decisions and solve problems.

Examination reform

There is no better way to judge the state of our education system than to reflect on what has happened with examinations over the past decade. We now have

- base line testing (age 5)
- KS 1 tests (end of Y2)
- KS2 tests (end of Y6)
- KS3 tests (end of Y9)
- GCSE (end of Yll)
- AS/A2 through Y12 and Y13

If this were not enough, we now have 'optional' tests in, for example, mathematics, for all other years, and it seems that most schools will, in fact, use these and there will also soon be

- world class tests in mathematics and problem solving.

Our government (and its predecessors) seems to think that this endless testing will improve education; far from doing this, it is one of the reasons why teaching is not attracting the 'born teachers' it so badly needs. Do we really believe that endless revision in preparation for tests is a good thing? Many classes start revision at least half a term before the national tests, so that any gains made in these tests are probably only transitory.

The Minister of State has recently announced an extension of league table to include national publication of Key Stage 3 results, although we all know that making comparisons based on the raw data in league tables is not a valid exercise. Obviously, we need to give parents information, but if we had an education profession that we trusted, league tables would be irrelevant.

Looking again at other countries, most do not have any *national* tests until age 18, and then in a much simplified form. For example, in New Zealand and China, there are two national tests (each of 3 hours) in mathematics at age 18. One of these is specifically for those wishing to specialise in mathematics at university, the other for school-leavers (and taken for entry to university in other subjects). Just compare this to our own system, where firstly we have competing exam boards (1 think that we are unique in this!), and where the recently introduced AS/A2 modules have further complicated matters; in mathematics most exam boards now have at least 20 modules!

Another problem, peculiar to mathematics and to this country, is our tiering system for GCSE. It is impossible to get a grade C on the Foundation Tier, and, if a pupil does not do well enough for a grade C on the Higher Tier, they are automatically awarded an unclassified grade U. This inevitably means that the great majority of candidates take the Intermediate Tier, and in so doing, receive inadequate preparation for A-level mathematics.

Tier	*Grade available*
Foundation	U G F E D ▨
Intermediate	U ▨ E D C B ▨
Higher	U ▨ C B A A*

This is obviously an unfair system as there is more than one way of achieving many of the grades, including the all-important grade C. In no way are the different routes equivalent!

Reform of our examination system is urgently needed but it must aim for a simpler system in which national exams only play a small part in the overall assessment with teachers trusted to provide local assessment that can be used mainly for diagnostic purposes.

Reform of teacher training

Here again there is chaos, with governments keen to use methods other than the traditional university route, introducing, for example, school-based training routes and graduate teacher training routes. There are also now plans for undergraduates to take options during their degree courses which would be part of the PGCE route.

But as with many recent initiatives in education, these do not seen to be based on any *research* into effective training of teachers. Most countries use a system of University Practice Schools (UPS) and local Partner Schools. The UPS is a normal, state school, with wide intake, but it attracts the very best teachers. All students in training have a least a period of observation in the UPS, although they will still undertake main practice in one of the local partner schools.

The UPS is also useful

- for longitudinal research and other educational initiatives
- as a centre for inservice for local schools
- as a school in which all university education staff can regularly teach.

It is akin to university teaching hospitals, and, above all, serves to emphasise the professional nature of the job of a teacher.

Finally, I have to add a word or two about OFSTED. I suggest that it be disbanded altogether and replaced by a sensible service in which HMI and LEA advisors combine to provide a local support service for schools, working constructively with them to improve provision in every state school.

Unless some radical changes, along the lines suggested above, are made to the educational system, I really do fear for its future. We urgently need a profession that attracts the most able graduates so that 'born teachers' readily come into teaching, certain of creative and rewarding career paths.

The Effects of Teacher Workloads and Other Factors on Mathematics Teacher Recruitment and Retention

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Introduction

We have not at King's been directly researching factors which affect the recruitment and retention of mathematics teachers, although the matter is clearly of immense national importance, as Oldknow & Taylor (1999) indicate. However as part of two current research projects, data was gathered which suggested significant issues informing the causes of teacher shortage which should be shared with policymakers. None of these issues will of course be of any surprise to anyone working within the English school system, but nevertheless it can sometimes be useful to have some evidence, even on a small scale, to support general views.

In the early part of the paper we will consider issues affecting recruitment, noting first a wide range of factors which influence whether undergraduate mathematics students consider teaching as a possible career, before focusing in on workload issues. In the final section we give a very small amount of data which relates to workload arising from the Key Stage 3 Mathematics Strategy and its possible effect on retention.

Recruitment - general factors affecting career choices

The first set of findings arises from an ESRC project (R000238564) *'Students' Experiences of Undergraduate Mathematics'*, which is being carried out jointly by members of the mathematics education and mathematics departments at King's College London and Leeds University (Sheila Macrae, Hannah Bartholomew, Dylan Wiliam, Margaret Brown, Tony Barnard, Peter Saunders, Melissa Rodd, John Monaghan, Alan Slomson and Chris Robson). Our aim was to work longitudinally with a single cohort of students during the three years of their degree course in order to understand better the reasons why they experience their mathematics programmes in different ways and why some maintain or develop more positive attitudes than others to the subject. The findings will therefore provide useful information about students who represent a major potential supply of mathematics teachers.

The study focuses on single honours, undergraduate mathematics students from two, traditional (pre-1992), city-based English universities. The universities were chosen because they are highly graded for both teaching and research and attract large numbers of well-qualified applicants. The average A-level points scores for mathematics students in both universities were 23 (QAA, 1998), in comparison with national average scores of 19 points (QAA, 2000). The percentage of female students admitted to mathematics courses in both institutions is approximately one third, which is slightly below national average figures of 38% females and 62% males (QAA, 2000). In one institution, the ethnic composition of the cohort is predominantly white (approximately 95%) while the other has around 45% British Asians, 45% white and 10% of Chinese origin. Thus between them these two institutions are producing large numbers of the type of graduates we would like to enter teaching.

We have recently completed the first year of this study. Although there are many data sources, both quantitative and qualitative, contributing to the research, we will just describe the two from which data has been extracted for this paper. A pre-course questionnaire (Summer 2000) was sent to all 230 students enrolled on single honours mathematics courses in each university. The return rate was over 70%. From an analysis of the questionnaires, we were able to select an initial cross-sample to reflect the cohort's composition in relation to, for example, sex, 'ethnicity', academic attainment, type of school attended, family background, living at home/in university halls, part-time jobs, career aspirations and so on. These students have been interviewed, in small groups (19 group interviews) and individually (28 interviews). In the course of the year, we broadened the sample both to address imbalance, notably in relation to ethnicity in one institution and to include a range of interesting cases, for example, students who failed mid-sessional examinations.

Of the 162 questionnaires returned, in answer to the question, 'Would you consider a career in teaching maths?', exactly two thirds (108) ticked 'no', while the remaining third (54) replied 'yes'. Students were invited to explain their answers. In the sections below most of the relevant comments are quoted so that the salience of some factors can be judged by the frequency of the comments referring to them. Inevitably some answers refer to more than one factor.

Students with parents who are teachers

Of the 162 students, almost a third (53) had parents who were teachers: both parents in the case of 12 students and an additional 34 mothers and 7 fathers. The total includes seven who were described as lecturers (three mothers and four fathers) in a variety of post-16 institutions. Of the 53 students whose parents were teachers, only seven (13%, in comparison with 44% of the students without teacher parents) said that they would consider a career in teaching. Even some of those seven added caveats:

> 'Yes, but not until it stops being a 24 hour job and the paper work is terrible.'
>
> 'Yes, but only to students I choose - i.e. hard working, driven and committed.'
>
> 'Yes, but at university. It would allow me to continue with a subject that interests me.'
>
> 'Depends - if I can't find a particular career I really want to do, I may like to go into teaching.'
>
> 'Good status, worthwhile job, pay not good though. Do not think I could do the job sufficiently well.'
>
> 'It's unlikely that I'd do it because of the pay, but I think I could be quite a good maths teacher.'

Only one of these 53 students sounded at all positive, if realistic, about teaching; she had ticked 'Yes' and added: 'My mother is a teacher so I know what it involves'.

The vast majority of students whose parents were teachers and who would not consider teaching as a career either stated that their parents had persuaded them against it and/or cited the *stress*, *long hours*, *administrative load* and/or *abuse* experienced by their parents, especially in regard to the perceived *inadequate pay* and *low status*:

> 'Parents are both teachers so have been put off that choice of career!'
>
> 'My parents are teachers (enough said!)'
>
> 'My parents are both teachers.'
>
> 'There are too many teachers in my family already and, anyway, they don't advise it'
>
> 'My parents were both teachers and don't recommend it.'
>
> 'Mother is a teacher (not of maths) and she advises against a teaching career.'
>
> 'My mother's a teacher and she has put me off it.'
>
> 'My family are teachers - I don't fancy it and they suggest I wouldn't like it.'
>
> 'I have seen for myself the stress that occurs in a teacher's life. It's enough to put anybody off.'
>
> 'My mother and father are teachers. My mother has retired through overwork. My father would retire if he could afford to.'
>
> 'Family members are teachers and they have either left the profession or don't enjoy it. Teaching has such a bad reputation these days.'
>
> 'My mother is a teacher and I've seen the stress she suffers. It's not worth it.'
>
> 'My father is a maths teacher and when I see what he has to do, the job just doesn't appeal to me.'
>
> 'My parents are head teachers. They give up over half their lives to their jobs. This is not rewarded by good pay and teachers are constantly criticised by everyone.'
>
> 'My sister's a teacher and advises me not to! A lot of work for ridiculously low pay.'
>
> 'Dad's a maths teacher. The hours are too long for the pay.'
>
> 'Both my parents are teachers - it's a crap job with crap wages.'
>
> 'Teachers are taken for granted and the job's less about teaching now and more about administration and teachers are constantly scrutinised as if they can't be trusted.'
>
> 'Dead end job, limited money, lots of abusive pupils - not worth it, in my opinion (both my parents are teachers).'
>
> 'Teaching is not highly respected like it once was. Who wants to go to work to be abused?'

Students without teacher parents who say they would consider teaching as a career

While 44% of 108 first year undergraduate mathematics students without teacher parents reported that they would consider a career in teaching, several added that, at this stage (before the degree course began) they would be open to a wide range of suggestions:

> 'Not totally sure about the idea at the moment.'
>
> 'Would not rule out any possibilities at this moment in time.'
>
> 'I'd consider many things.'
>
> 'No definite career plans.'
>
> 'Possibly - not certain.'

Only one student confessed to anything that sounded like a longstanding vocation:

> 'I have always wanted to teach special needs children'.

However several others thought they might like to teach because they *liked children*, they *enjoyed helping others* and *wanted to work with people*, or they *enjoyed mathematics and wished to share their enjoyment*:

> 'I love children.'
>
> 'I enjoy working with kids.'
>
> 'I like helping people.'
>
> 'Maybe [I would consider] teaching (don't laugh). I'm a people person.'
>
> 'I enjoy working with people.'
>
> 'I like working with young people and I would like to give people a chance to enjoy maths like I do.'
>
> 'I think that people can gain a lot from studying maths and I think I could present it in a fun and interesting way.'
>
> 'I would enjoy working with maths every day and helping others enjoy the subject.'
>
> 'I don't mind what I do as long as I work with maths.'
>
> 'I enjoy maths and would like the interaction with other people.'
>
> 'I want job satisfaction rather than money - that's what you get from teaching.'

Some students had already had some *teaching experience which they had enjoyed*:

> 'I enjoyed tutoring a girl in GCSE maths.'
>
> 'I have helped teach maths to GCSE students during A-levels and enjoyed this. The benefits of being a teacher (pay, conditions) would have to be improved though.'
>
> 'Enjoy doing it to friends and siblings.'
>
> 'Enjoyed teaching cadets at school and did two months teaching on a summer camp so know I'm capable of it.'
>
> 'I've done three years of work experience teaching maths at my secondary school and loved it.'
>
> 'I quite like the idea of passing on my knowledge to others. When I was 15, I did teaching for my work experience.'

Some students focused on the *importance of the job* and *the worthwhileness of sharing their knowledge*:

> '[I would consider teaching] because it is important.'
>
> 'Yes, because there aren't a lot of good maths teachers around.'
>
> 'It would be good to pass on the knowledge that I have acquired.'
>
> 'I like the idea of passing my knowledge on to the next generation.'

Encouragingly, several mentioned as a factor their *positive experiences at school working with good mathematics teachers*:

> 'The teachers at my school made the job interesting and a challenge.'
>
> 'I had a good teacher who influenced me a lot and I would like to do the same to others.'
>
> 'I enjoyed school as a student and feel I would enjoy it from the opposite view point.'
>
> 'Inspiration of my own maths teacher. Have already done work experience and enjoyed parts of it whilst being discouraged by other parts.'
>
> 'I have enjoyed the work I have done with young people. I would like to have an affect on people as my maths tutor has on me.'
>
> 'I'd like to do for others what my teachers did for me. I enjoy helping people, especially to understand maths.'

While some thought they might like to teach they did have certain reservations, relating to their *own suitability* or other factors:

> 'I would consider it although I don't think I would be a very good teacher.'

'I think it could be a fulfilling career but am not sure if I'd be suited to it'.

'I would like to inspire people but I'm wary as I am aware that teachers are underpaid and overworked.'

'I wouldn't consider teaching secondary school pupils but I would at least think about teaching A-level or higher education students.'

Happily, not everyone agreed with the view of teaching as unattractive:

'Lots of holidays and well paid.'

'Bursaries offered for qualifying. It's a respected profession.'

Students without teacher parents who say they would not consider teaching as a career

As for the students whose parents were teachers, *low pay*, *poor conditions*, *pupil abuse*, *stress* and *workload* were common reasons for rejecting teaching as a career:

'It's a hard job and it's not well paid.'

'Underpaid/high stress'

'Too stressful.'

'Low pay and poor conditions.'

'Don't like either teaching or the pay.'

'Little money and too hard

'Rubbish pay and annoying rude students.'

'Too stressful for the salary that maths teachers get.'

'I suffer much disillusionment over a teaching career. It appears to be trying, badly paid and thankless.'

'Teachers are just so badly paid for all they have to do and put up with.'

'Don't want to go into teaching due to low wages and badly behaved kids.'

'Poorly paid for a huge amount of work.'

'Not enough money, not enough variety within job.'

'Poor pay.'

'It's not well enough paid.'

Other students also spoke about the problems of dealing with badly behaved pupils. The word 'abuse' is frequently used in connection with teaching, presumably arising in the school culture which most of the students have only just left.

> 'Teachers receive very low pay and are subject to such a lot of abuse from unruly pupils.'
>
> 'Want to be in a higher paid job and I could not handle teaching people who would give me abuse/hassle/stress.'
>
> 'Couldn't handle the abuse from the pupils.'
>
> 'I know what the kids can be like.'
>
> '[I would] never [consider teaching], going from my past experience of pupil/teacher relations - i.e. lack of discipline.'
>
> 'I could not be bothered trying to teach people who would not want to learn - such a waste of time and energy.'
>
> 'Did work experience in a school. It put me off for life.'
>
> 'I went to school and I know how teachers are treated.'
>
> 'I would just hate to be a teacher because they get it so hard from the kids they teach.'
>
> 'Children are uncontrollable and the pay is not good enough for having to put up with all the abuse they get.'
>
> 'I just couldn't take the abuse.'

Several students considered that a mathematics degree would enable them to earn more money with less hassle:

> '[Teaching is] not as well paid as other careers that maths gives access to.'
>
> 'Teachers are not as well paid as other jobs I could do with a maths degree.'
>
> 'Underpaid compared with other career prospects.'
>
> 'There are easier ways of earning a living especially with a maths degree. It has such a bad image and children are so irritating.'
>
> 'I could earn more money with a maths degree than most teachers'
>
> 'I could do lots of jobs with a maths degree that provide more satisfaction and much more money.'

As for those with teacher parents, reasons for rejecting teaching as a career included doubt as to their own suitability, as well as the nature of the job:

> 'I'm not particularly fond of children.'
>
> 'Don't have the necessary skills for teaching - e.g. patience.'
>
> 'Have no patience.'
>
> 'Have a bad temper.'
>
> 'Don't have the passion to become a teacher.'

> 'I wouldn't consider a career in teaching at all as I couldn't teach the same thing year in and year out - too repetitive.'
>
> 'Not much career advancement. I cannot think of anything worse than spending all my time learning maths and then going back to school to teach it'
>
> 'I've been in school for 14 years already - I certainly don't want to go back.'

Thus for students who did not have parents in the profession, factors discouraging them from teaching were not dissimilar to those who had teacher parents, except that there was more concern about *abuse*, *inadequate pay* and *low status*, with occasional comments about the *repetitive nature* of the job and *lack of career progression*. There was correspondingly much less mention of *stress*, *heavy workload* and *administrative load*, which were more salient factors for students who had closer experience of the demands outside the classroom.

Recruitment and retention - data from student interviews regarding workload issues

In addition to the questionnaire data many students were asked for further elaboration in interviews. Since it is impossible to give further detail on all factors raised in the questionnaire, we will focus only on data which relates to workload concerns. The four examples selected are all taken from interviews in late Autumn 2000 or Spring 2001 with female first year mathematics students who did not want to teach, and who felt they were well-informed about the job since they had one or more parents who were or had previously been teachers.

Su: Definitely not, no. I've seen the bad side of teachers and, you know, like all the work they have to do. They may have holidays, you know really long holidays, better than other jobs, but they don't really because they have so much work to do in the evenings and weekends as well, they're taken up with marking and preparing and that takes hours and my mum has to go in to school during the holidays. I must say I think it's a very stressful job and I wouldn't even think about it.

Int: So would your mum say: oh don't do it?

Su: Definitely. She's said it to me loads of times. My dad was a teacher for a while and he gave up. He just couldn't stand it and he was just so conscientious and he spent hours and hours until he eventually said, 'I can't do this any more'. He had a huge career crisis thing and he nearly had a breakdown and he's now an organist. So it was like a drastic career change.

Int: Yes, that sounds very different from teaching.

Su: Yeah, yeah he likes that. Much less stressful.

* * * *

Hana: I don't know what I want to do. But I definitely don't want to be a lecturer. Teaching of any sort I don't want to do whatsoever.

Int: Because?

Hana: Because I've seen what it did to my parents. My mum retired basically because of stress and it just doesn't appeal. I just, because of my parents both being teachers I know a lot of teachers and it, you speak to them and you just don't want to do anything to do with education. Education has become so destructive to teachers, you know. They say things, like, don't whatever you do, don't be a teacher. But you don't need to be told because you can see what it's done to them. They're so ground down and it's just not fair because my mum was such a good teacher and she worked so hard. My dad, he's still teaching but he would give up tomorrow if he could find another job. But he's like stuck with it and so are a lot of my parents' friends, stuck with jobs that they don't enjoy any more and are giving them like real stress so they're ill with it. It doesn't make sense because they really do work so hard. So I don't know what I want to do, I just know what I don't want to do.

* * * *

Int: I think you said in your application form, on your questionnaire I mean, that you wouldn't consider teaching, but your parents had been teachers.

Flo: Yeah that's right.

Int: So what did they say about teaching.

Flo: They think it's awful. They think it, my parents, when I was younger they were teachers, and then, they were married to their jobs, they were always working, they brought their work home with them, that's what I don't want to be able to do. I want to be able to go home in the evenings and not take any work home with me. My parents always did that and they had very little time for each other or for me and my sister, they were just always working, and I think it's just a bad situation to be in, I'd like to have a nine to five job that stops at five, yeah. Because they're still like that now. My mum went on to become a special needs teacher, and my dad went on to become psychologist and they still bring work home with them so it hasn't got any better.

Int: But that's put you off teaching?

Flo: Yes it has, because even when I was little I couldn't understand why they were always working and I thought, I don't want to have to do that and my parents both said to me, 'don't even consider teaching because you're never finished' and I wouldn't want to be a teacher, but I think my parents have got so they'd always be working even, because my dad's a psychologist now and he's just the same, always working. It's just become a habit and I don't want that.

* * * *

Int: Would you like to be a maths teacher?

Mo: No, certainly not. Both my parents are teachers, so they kind of put me off of it.

Int: What did they say?

Mo: Well, they said things like, don't be a teacher because it's just not worth it. Everybody's always getting at them; the government are always criticising them and Ofsted drives loads of them to nervous breakdowns and loads are off sick and that. It's such hard work nowadays and whatever they do, it never seems to be enough. People think teachers get long holidays but they don't, you know. My parents go in over half terms and in the holidays. They just work so hard and I think it's such long hours and not very good pay. And I think that with a maths degree I could so easily get a much better paid job with much less hassle than my parents have to put up with.

The quotations from these four students suggests that workload is a major reason why only 13% of first year mathematics students with teacher parents would consider teaching, and why this is so much lower than the 44% for other students who seem less aware of workload problems. These personal stories about their parents also suggests that workload is a major factor in retention problems (these four students had between them one mother who had retired early and one father who had made a radical career change due to stress). As the next section demonstrates, stress and workload factors and their effects on retention may in the short term become more acute.

Retention issues related to the Key Stage 3 Mathematics Strategy

We at King's (Hamsa Venkatakrishnan, Dylan Wiliam, Terry Furlong and Margaret Brown) are also currently involved in a small-scale project *'Evaluation of the Pilot Key Stage 3 National Strategies for Mathematics and Literacy'* in co-ordination with and funded by the Association for Teachers and Lecturers (ATL). The 2-year pilot, which started officially in September 2000, was interrupted after only a few months by an announcement that the Strategies would be implemented nationally from September 2001. So findings from the first year of the pilot, quoted below from the Interim Report (Furlong, Venkatakrishnan & Brown, 2001) give only a little advance notice of what may now be happening on a larger scale.

Our data on this project is not representative as it is restricted to a small number of ATL members who volunteered to respond to questionnaires and telephone interviews. While it is possible that the respondents feel more strongly about the

Strategy than non-respondent ATL members, on the whole for historical reasons ATL members are likely to be less militant and in higher status schools than members of other teaching unions. The mathematics teachers who responded to our main questionnaire are from 30 schools, including at least one school in each of the 17 LEAs in the pilot. 22 teachers responded to a preliminary questionnaire and 10 participated in telephone interviews.

Responses from teachers reveal that they welcome many features of the Strategy, including the emphasis on mental calculation methods, pupil reasoning and oral work with the class. The clarity of the objectives and the examples in the Framework document, and the quality of the training, were generally praised.

Some teachers were happy that the Strategy encouraged pupil autonomy and participation:

> more of the investigational things...it's made for a more happy, dynamic environment to work in.

Others felt professionally belittled and dissatisfied with the amount of content specified:

> I believe that I am no longer a facilitating mathematician. I have become a child-minder who is force-feeding a diet of supposedly healthy food which will soon be vomited back up and never become absorbed in the life-blood of my students. They will not become people who want to do and enjoy mathematics.

However the main problem was with the lack of time available to disseminate and discuss with colleagues, and to re-write plans and schemes of work, which most schools felt to be necessary if they were to conform to the requirements:

'There is no time to do everything properly – everything is rushed.'

'We do feel that it is just another thing to be hit with ... not enough time!'

'Too rushed – we haven't had enough time to set it up. – Need time for reflection and development. Too much to do in too short a time.'

It was clear that the lack of time for implementation had led to additional workload; for example, half the schools responding had re-written their schemes of work for

Year 7. For some schools the implementation difficulties were exacerbated by staffing shortages. A Head of Department commented:

> The Gov / schools can devise the 'best' schemes on paper but unless there are qualified and motivated staff to deliver these schemes, we are all wasting our time. Over the last 6 years I have had over 20 temporary supply teachers. After 17 years of teaching myself I am seriously considering resigning and pursuing another career.

Another of the 30 teachers had already resigned because of the additional burden:

> Workload increase as a result of yet more changes is the most serious issue in my opinion. I have resigned w.e.f 31/08/01 from my full time position as Maths teacher mainly because of workload, the KS3 scheme being part of the reason. There are many other colleagues who are close to this desperate situation …

Conclusion

The responses of first year undergraduates suggest that there are perceived to be positive features about teaching, especially the relationships with both children and mathematics, which might attract them towards a decision to take it up as a career. Since this is especially true of those who have had some experience, in coaching or work experience at a school, encouraging such opportunities would seem fruitful.

But over half the students are put off by perceptions of low salary, slow career progression, lack of public respect, abuse from pupils, workload and stress. To the Government's credit it is somewhat belatedly tackling the salary and progression issues, but appears unaware that part of the process, crossing the threshold, itself has significantly increased workload and stress. There is also increasing government financial support to enable schools to tackle pupil behaviour. It is clear that such improvements need to be publicised more widely if they are to affect recruitment.

However one of the most serious problems is the overwhelming reluctance of undergraduates with teacher parents to follow them into a teaching career. This group should be a major source of teacher supply. Although the factors mentioned by other students are cited, it seems that students are especially put off by the heavy workloads they have seen their parents carrying. In the worst cases this has led to breakdowns and early retirement due to stress. Following the campaign from the teacher unions and the KPMG enquiry into teacher workload, there will hopefully be some action to reduce workload, although this may be limited by financial constraints. Unless there is a real lightening of the workload teachers will continue to advise pupils in general, and their own children in particular, against teaching as a career. Thus ministers who are keen to enhance recruitment and retention need to listen hard to teachers' views about what it would take to make teaching a more attractive and rewarding career and how the stress and workload could be lightened to more realistic levels.

But even as workload is becoming a central issue, there is evidence from pilot areas that government policy in the form of the National Strategy for Key Stage 3 Mathematics is significantly increasing the workload, sufficiently to trigger additional resignations from mathematics teachers. Some of the stress could have been reduced by allowing more time, for planning and, for example, for publishers to prepare suitable materials and schemes of work. Simultaneous implementation of changes at KS3, GCSE and AS/A2 should have been avoided. These mistakes of over-hasty implementation for quick political gain have been made by the previous government at the time of the national curriculum, and by this one in the primary literacy and numeracy strategies (e.g. Johnson & Millett, 1996; Earl et al., 2001).

We will clearly not begin to solve the teacher shortage until the government takes seriously the fact that a valued teaching force which is fully involved in determining policy at national and local levels, and as a result is more committed to making changes, is more essential to high educational standards than any number of top-down initiatives dreamed up by government advisers.

There are recent signs that the government is at last becoming aware of the effect of their own initiatives on teacher retention. The second report of the DfES-commissioned Evaluation of the Implementation of the National Literacy and Numeracy Strategies in primary schools warned them:

'While feelings of overload and stress are common side effects of many large-scale approaches to school reform...there is a tendency for reformers (as well as the general public) to minimise the problem. This is understandable because of the sense of urgency about the need for change. However feelings of overload and stress can have negative consequences for the daily performance of teachers and their willingness to remain in the profession, as well as for the general attractiveness of teaching as a profession...' (Earl et al., 2001, p.83)

The White Paper *Schools Achieving Success* reflects recognition of this point in a pledge to make the Key Stage 3 implementation more flexible than had been the intention in the pilot areas:

> But schools need not seek to do everything at once...We have encouraged LEAs to deliver training for Key Stage 3 flexibly to suit schools varying needs and circumstances and in particular to make sure the training does not unnecessarily exacerbate recruitment and retention pressures, where they exist. (para. 3.8, p.19)

At last we have some evidence that the Government is starting to realise the connection between their own policies and the growing teacher supply problems; there is however still some way to go in considering positively which policies might increase the attractions of the job.

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Why Do People Decide to Train to Teach?

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Abstract

As a by-product of a larger research project about teacher attitudes we asked more than 40 practising teachers what it was that attracted them to train to teach. The diversity of their answers creates problems for those whose task it is to increase recruitment since no single approach seems likely to make a major contribution. There are however some implications for those who interview candidates for teaching

Background

At a time of teacher shortage, any indication as to why an individual should want to teach is likely to prove helpful in the development of a strategy for attracting people of talent into the profession. As part of a broader project (outlined below), we have gained some insight into this particular question which, we believe, challenges the received views of the typical applicant for initial teacher training, and his or her rationale. Anyone who has ever interviewed prospective entrants for teacher training will be aware of the diversity of reasons candidates give for wishing to train. They may have suspected that all too often candidates' objectives seem more concerned with convincing interviewers of their integrity than with allowing their less altruistic motives to slip through. As one of our interviewees, an experienced and successful second-in-department admitted during the course of her interview,

> I didn't go on to maths because I wanted to teach. I still don't want to teach. If somebody offered me a job doing something else for the same money I'd be gone just like that, but I know now that I am too old to retrain. I have a mortgage and two children – I have accepted that I am going to be a maths teacher but not because I want to be.

This paper explores the pre-career decisions of serving teachers of mathematics which were articulated during interviews conducted as part of a wider research project into teachers beliefs' about, and attitudes towards, mathematics and its teaching. The interviews were semi-structured, with an identical sequence of questions posed to all interviewees but with interesting issues being pursued before subsequent questions were asked. The interviews lasted, on average, around 30 minutes. Interviewees were volunteers identified subsequent to a questionnaire survey of teachers of secondary mathematics which was undertaken in three areas of England. The survey (reported in Andrews and Hatch 1999, 2000) yielded almost 600 responses, and led to around 100 volunteers; of these almost 50, forming a representative sample of teachers of secondary mathematics working within the maintained sector, were interviewed. Importantly, many of the interviewees had been teaching for a good number of years and, we suggest, had no motive for concealing their real motives for becoming teachers. Their accounts were, we argue, likely to be open and honest report of their rationales.

The first question in the interview schedule was *'what attracted you to mathematics teaching as a career?'* This was intended to act more as a warm-up question than one we expected to find particularly enlightening. However when we analysed the responses it became clear that a fascinating catalogue of reasons for teaching had emerged. Most informants offered a range of reasons for deciding to teach which seemed to indicate that this was not a straightforward decision-making process. The interviews were analysed using a grounded theory approach, (Glaser and Strauss, 1967). Eighty-eight different areas of response were identified which were then grouped into thirteen categories:

- Response to mathematics as a subject
- Working with people
- To affect pupil experience
- 'I always wanted to teach'
- As a decision taken after graduating
- To escape from previous employment
- After having had children
- The experience of knowing teachers
- The job was suggested by someone else
- Having some pre-experience of teaching

- The job conditions appealed to me
- A sense of vocation

We report first on the outcomes and discuss later whether they contain implications for recruitment.

Response to mathematics as a subject

It was, perhaps, not surprising that a substantial number of informants gave enjoyment of mathematics as their main reason for being attracted to mathematics teaching. Generally it was school mathematics that was most frequently mentioned, *I have a memory of maths at school and enjoying it,* with university mathematics appearing much less enjoyable, *at university I lost confidence, I lost interest, I lost enthusiasm for it.* Some informants felt that they were good at mathematics or that it was their best subject at school. Others seemed to enjoy the closure of mathematics in the sense that one can solve a problem and know that it is correct - a reason we hear frequently proposed by PGCE applicants. A few who had continued to enjoy their mathematics at university saw teaching as a way of remaining in touch with the subject. The fact that *you didn't have to write long essays* also figured as a reason for liking maths more than other subjects. This positive response to mathematics at school was the most frequent justification cited by our sample.

Working with people

Many interviewees spoke of their motivation for training to teach as deriving from an interest in working with people, *I just like contact with people and particularly children, I find them very interesting*. For some, their interest was specifically in children, *I enjoy working with children, that was the main thing*, whilst others spoke of their experience as teenagers with voluntary groups, *I was already involved with guides and various youth groups*.

Some felt that as teachers they would be able to make a difference to the lives of their pupils, *I think we can impose some of our own interests and beliefs onto the kids*. For others, teaching was a worthwhile act that would bring them personal satisfaction, *I* *found I like children (...)Eleven to sixteen I thought, I can cope with that and I can get involved with my subject and I'll still be working with children. And it's probably the best thing I've ever done.* These ideas arise again in the next section, which is concerned with mathematics itself.

To affect pupil experience

A considerable number of informants wanted to teach mathematics because they felt they would be able to influence their pupils' response to mathematics. For some this meant sharing their enjoyment of mathematics, *I think the main reason was enjoying maths and wanting to share that.* Others explained this against a backdrop of the number of people who dislike mathematics, *I never saw it as a bogey subject. It wasn't something to be dreaded; I quite enjoyed it so I thought why can't everybody else enjoy it as well.*

Others wanted children to have a better experience of mathematics at school than they had, *I wanted to make children enjoy their maths the way I hadn't when I was at school – to sort of develop a different way of teaching.* Whilst for others the rationale was to share the good time they had had with mathematics at school, *I had such a good time at school that I wanted everybody else to have the same experience.*

Some described a developing interest, as a consequence of the ways in which their teachers taught, in the ways that children learn: *I enjoyed the subject because I liked the teacher because she talked in a way I could work with and then there were other people in my class that couldn't do maths because they couldn't work with her and I felt there's something going on here with the way somebody delivers maths and the way it's absorbed.* Others commented on the effect a good teacher had had on them, *I liked my maths teacher at secondary school. She inspired me (...) my experiences of the lessons were good ones.*

'I always wanted to teach'

A substantial number of interviewees indicated that their decision to teach was long held and unshakeable, *I always wanted to be a teacher and I never changed my mind.*

Frequently such teachers seemed unable to explain their reasons. For some the desire to teach predated their knowing about mathematics. One informant commented that, *when I was four I came home to my Mum and said I wanted to be a teacher and never changed my mind*, whilst another said, *(I intended to become a teacher) when I was little. I just liked bossing people about!*

Others' choice of **secondary mathematics** teaching linked their liking for mathematics with a preference for older children *I don't like little children*. Or as another respondent commented, *I felt mathematics was my favourite and most loved subject and for some reason I always wanted to teach. So the mathematics teaching just came by joining up the two things.*

A decision taken after graduating

The majority of informants did not go to university with the long term intention of teaching. For a number, a PGCE was one of several obvious things to do after a mathematics degree, *I wouldn't say that teaching was my – was ever really in my mind. I went to university to do maths. (..) Having been to university and done my maths somebody said why don't you teach so I thought about it and eventually did do a teacher training year. By that time I thought perhaps that was what I did want to do, although I wasn't a hundred percent convinced. It was my teacher-training year that convinced me.* Some were open in admitting that they did a PGCE because they wanted the extra year as a student or some space to think about what they really wanted to do. One informant said that, *it was another year being a student which I was enjoying, so I thought I'd do it*, while another commented that *at the time it was almost as if I hadn't anything better planned to do but as it turns out when you're doing a PGCE, you either really get on with it and love it or, if there's any doubt, I don't think you'd last the course.* A third said that she *finished university, went to Papua New Guinea for two years, travelled back overland and got back here with infective hepatitis and then thought 'oh dear what can I do, I'd better go to college for a year.'*

For some it seems to have been more a rejection of other job possibilities. One colleague commented that, teaching, *a little bit by default, university, not quite sure what to do, did a teacher training year, the sort of careers that had been suggested didn't appeal to me, teaching sort of did and I dropped into it*. Another observed, *I went for quite a lot of accountancy interviews – I didn't fancy it. I just couldn't see myself working in an office.*

Several had the explicit intention of finding work in professions other than teaching but found themselves, unable to get the jobs they wanted, being offered supply teaching and finding that they liked it. One such colleague commented, *I wasn't going to be a teacher at all, I was looking for other jobs, I got offered locally a supply. It was in the days you didn't have to qualify. I did a term basically of supply and I did two terms in a prep school and then I did a PGCE.* Another said, *it was the low point, trough, on the graph for employment, I was unemployed and by Christmas I was getting fed up and I saw an advertisement for a teaching job in the newspaper.*

To escape from previous employment

Many of our interviewees had come into teaching to escape, in a very real sense, from what they had been doing. Some, inevitably, had been threatened with redundancy, *my degree is in production engineering and initially I went for employment in the real world and unfortunately at that time it was recession and rather than go unemployed for twelve months I went to do a teacher training course.* Others were dissatisfied with the nature of the jobs they were doing; *I had actually fancied going into teaching directly from university, (..) but I wasn't ready for it. (..) So I went out into the big world (local government) and got nearly four years' experience of other things first. And then eventually realised that the thing I'd first thought of was probably the thing I did want to do.* Another informant commented that *I didn't really know exactly what to do with my economics degree and found myself drifting into a sales job which was OK for a few years but it turned sour after a while. Looked at my* *options, economics degree seemed to lead to two things, which would be either teaching or accountancy. I wasn't really that interested in accountancy.*

Indeed, for a substantial proportion of the mature applicants to the profession, the desire to break away from an unsatisfying job was very strong. One informant commented that she had *worked for three years (before doing a BEd degree) and then I realised I was wasting my time. I managed shoe shops. It didn't have much to offer*. Another admitted that, *this is going to sound awful. In the first instance basically to get away from the awful job I was in and do something different. Initially really to get away and give me some space and the opportunity to do something different.*

After having had children

As is apparent from work in admissions to a primary B.Ed degree, many women enter teaching as a result of having children and realising either that they like working with children or, encountering schools for the first time since their own childhood, find them attractive places to be in. It is, perhaps, a little surprising that this reason was also given by several secondary teachers. One said that *when I'd done my A-levels I decided I'd had enough of education and I went out and got a job. And then when my children were small I decided that I wanted to go back and start again.* A similar theme was picked up by another who said that, *I found I like children (by going to a playgroup with her own children). I was working in a playgroup and I liked working with children and the playgroup was based in an infant and junior school and very often I'd go into other classes as well and help out with other things as well.* Another commented that *trying to find a secondary school for my son (..) going round the secondary school, going in and just how maths had changed since I was at school (..) and thinking this is something I could do, I want to do.*

The experience of knowing teachers

Many of our informants seem to have been influenced by a particular teacher from the days of their own schooling. One said that, *I think it was probably my maths* *teacher who swung it in the end because she was able to explain things and I wanted to emulate her*, while another commented that, *I liked my maths teacher at secondary school. She inspired me (..) my experiences of the lessons were good ones. I think that in a sense made me decide I'd quite like doing this. I'd like to be something like the same kind of person and deliver a lesson where the kids thought – yeah that's a good teacher.*

Others had had contact with teachers which put the idea into their head. One informant commented that, *my sister's a primary school teacher, my father taught in a technical college, so it had always been a profession that I'd been aware of, if not something I had aspired to.*

The job was suggested by someone else

A few recounted that they had it suggested by aptitude testing of some kind, *and when I did my psychometric testing the three profiles came out as accountancy, army and teaching.*

One of our interviewees was sufficiently old to recount experience from the fifties, *In the fifties when I was at school, if you went into the sixth form your careers advice was are you going to teach or nurse.* This attitude was still around in the sixties when the second author was teaching in a girls grammar school. There the received wisdom was that if you were not quite good enough to apply for university, you automatically applied for teacher training college. A large number of the staff of the school were ex-pupils who had taken this advice! These are echoes from a world in which the options for mathematics graduates were quite different from what they are now. Yet even then there was a shortage of mathematics teachers.

In one case the interviewee only remembers that teaching was suggested, *Having been at university somebody said why don't you teach and so I thought about it and eventually did a teacher training year.* And in another case the suggestion came from a rather unlikely source, *I was going out with a girl who was two years younger than me (...) and she suggested I did teacher training.* For others the suggestion seems to have been implicit, derived from knowing teachers who were happy in their profession, *My sister was a teacher and she enjoyed doing it which made me wonder what she enjoyed about it and if I'd like that kind of thing.*

Having some pre-experience of teaching

This seems also to have been a significant motivator for a number of people. It could have arisen it many different ways . Many schools and colleges provide a structure of work experience, *I wanted to go into teaching, just that, I (had done) work experiences and holiday jobs. I tried other things and found them very dull.* Others were drawn into tutoring people who were struggling:

I started tutoring maths when I was at sixth form college. I didn't actually think of doing it (teaching) before that. (..), Throughout university I carried on doing it and it was nice in the summer holidays or whatever to do it.

Some took a temporary supply teaching job and enjoyed it :

I wasn't going to be a teacher at all. I came out of university. I got a job supply teaching, it was half and half science and maths and I didn't enjoy science teaching at all and I loved the maths teaching.

A few interviewees were drawn into teaching by doing VSO:

I don't think I wanted to teach originally. I did VSO in Papua New Guinea and I chose to do teaching because if I'd chosen to do computer science or something then I'd probably have been in a big city. So I thought I'd do teaching and I enjoyed that.

The job conditions appealed to me

Perhaps surprisingly, and in a way, encouragingly, only two people referred to job conditions as being important in their choice of career. One of these said, *to be honest the reasons that I went into teaching were holidays, pay, time – all the issues outside school.* It is possible, of course, that some of the late entrants had considered conditions of service when were thinking about juggling family and career, but felt it too obvious to mention.

A sense of vocation

Teaching is frequently described as a vocation, but few people referred to it in this way. It is possible that those colleagues who had always wanted to teach could be seen as having a sense of vocation, although only one informant specifically mentioned the word in its religious sense, *I think it was, it's a sort of spiritual thing, it was a Christian conviction that that was where God wanted me*. Perhaps it is possible, in modern terms, to interpret the statement, *I felt I wanted to do a job where I was putting something back*, as expressing something equivalent to a vocation.

Discussion

The evidence of the above shows that people become teachers for a variety of reasons and that serendipity seems as strong a career determinant as a well-considered career plan. Many interviewees became teachers for reasons unrelated to specific desires to teach mathematics but none the less, became successful and enthusiastic practitioners. It seems clear that not all the justifications discussed might inform teacher recruitment campaigns although there will, we suspect, always be those with a sense of vocation or an in-built desire to teach to whom advertising might be targeted. This does not mean, however, that other groups should go unacknowledged. We suggest the following points for consideration.

(a) It is likely that measures to improve the average pupil's experience of mathematics at school would result in many more people seeing teaching as a career option. The experience of learning mathematics at school appears more significant than the experience of learning mathematics at university at least for those who do decide to teach. This seems particularly apposite when considered against the large numbers of intending teachers who report poor experiences of university mathematics (Goulding, Hatch, Rodd in preparation). One can only conjecture whether more mathematics graduates would be prepared to enter teaching if their university course had not destroyed their pleasure in mathematics.

(b) The evidence suggest that working with people is an important motivator for many. We suggest that recruitment campaigns should include and put emphasis on the social aspect of teaching. The 'you never forget a good teacher' campaign would seem to be supported by our data as many of our informants remembered good teachers. Equally, however, a number recalled poor teachers on whose efforts they felt determined to improve, although it is difficult to see how recruitment strategies could be based on this.

(c) The decision to train to teach after graduating seems to be affected for some people by quite small events. The availability of advertising in mathematics departments, together with taster days seems therefore to be valuable.

(d) Interviewers of PGCE candidates traditionally look for some 'real' or 'tangible' commitment to teaching. Applicants who have been unemployed or made redundant have often been looked at unfavourably. The evidence here is that interviewers might adopt a more liberal stance in their use of these criteria and take more chances. Of our informants who offered 'shaky' justifications for teaching, some were known personally to us as highly successful teachers in our partnership schools.

(e) It would be helpful to long term recruitment if the drop out rate from PGCE courses was viewed as a necessary evil so that schools of education could afford to allow students to explore whether they really want to teach.

(f) Our sample showed a significant number of women entering teaching after having children. It would seem sensible to focus advertising campaigns on such groups.

(g) Experience of being a teacher prior to the decision to train to teach seems also to be a significant factor. School pupils' work experience, located in schools, would seem a useful means of helping people make their decisions in respect of teaching as a career. Some informants mentioned being asked to help with junior forms in their own school as a factor in their decisions. For older applicants it may be helpful for schools to acknowledge this and create appropriate facilities for potential applicants to spend some time in school. This could possibly be advertised to parents.

(h) A substantial number of people were introduced to teaching by third parties, many of whom were teachers themselves. It would not be inappropriate to suggest that teachers themselves might be more active in suggesting teaching as a career to their pupils. If we are to attract more people into mathematics teaching then all involved need to talk more positively about the profession to pupils, family and friends. We are aware that many of today's PGCE candidates will have been cautioned against teaching by family or friends as, indeed, had one of our interviewees, *My mother was a teacher and strongly advised me against doing it*, and it has, perhaps, been fashionable of late to say 'whatever you do, don't teach'. Inevitably, there are frustrations, but recruitment is unlikely to be helped by colleagues continually moaning in public.

(i) Our results here do not lead us to believe that teachers' conditions of service are of great significance in people's decisions to teach. Clearly it cannot be ignored because we have not gone beyond recruitment to consider notions of retention. Teaching is hard work. It is intellectually, emotionally and physically demanding and its practitioners deserve to be paid adequately for their efforts.

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Plug That Bath!

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Abstract

Using the metaphor of the classic mathematics problem of a bath being filled without the plug being put in place, this paper looks at the issue of the loss of experienced, good quality mathematics teachers, explores why they may be leaving and suggests some initiatives for their retention. It is intended as a starting point for creative thinking and the development of strategies that could be considered by government. The paper draws on professional experience rather than on hard research data.

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Introduction

> A bath is being filled by two taps. Together they deliver water at one litre per minute. The plug has not been put in. Water is running out of the bath at 0.6 of a litre per minute. How long will it take to fill the bath?

The government may have expected congratulatory headlines in September as the recruitment to Initial Teacher training appeared to be buoyant once again. However, rather than congratulations, the government was subjected to a barrage of negative stories focusing on teaching shortages: a school in Norfolk held back its starting date, a school in Devon did not fill two mathematics vacancies due to lack of appropriate candidates, a school in St Neots is paying £26000 for an untrained humanities teacher from Chicago and schools in Peckham are recruiting from Russia.

With the current estimates of job vacancies ranging between 3500 to 8400 (Mansell 2001), solid data is evasive. During July the TES advertised over 60 vacancies for mathematics teachers. Current advertised posts stand at 43. Conor Ryan (Ryan 2001) gives a figure of 410 vacancies out of an estimated 19 500 secondary mathematics posts. Given the reports of vacancies being filled by less than ideal candidates and by non-specialist teachers, the real shortage of mathematics teachers may be much higher. Whilst there has been a rise in people training to be teachers of mathematics the situation is not improving quickly enough. Just as it is foolish to try to fill a bath without putting in the plug it is foolish to try to solve the problem merely by training new teachers. The issue of retention of good mathematics teachers requires immediate attention. Through the Mathematical Association and my work in ITT and CPD I am privileged to meet many highly competent and enthusiastic mathematics teachers. How can we enhance their professional life so that they remain a source of inspiration to the next generation?

Who is leaving and why?

There have been anecdotal reports that the creation of 'Numeracy consultants' for Key Stage 3 has taken some very good teachers out of their departments. These would (one hopes!) be 'exceptional teachers'. That is, the better teachers in a LEA are being taken away from teaching pupils on a regular basis to provide support for a number of teachers. One school has lost both of its mathematics specialists and is left with only non-specialists to teach the subject. Such initiatives can cause tensions for the teachers who decide on a career change and the schools they leave. However the sharing of best practice is an integral part of the raising of standards and it in inevitable that these teachers' expertise will be lost to an individual school for a period of time but that many other schools will be advantaged.

Overall, the teaching workforce is ageing and consequently experienced staff will be retiring. Some will be taking early retirement for a range of reasons. How might they be persuaded to stay on? Additionally, there is a problem with 30-40 year-olds who are leaving. They are creating an 'experience gap' which means that more and more pupils are being taught by new-ish teachers: keen and enthusiastic but without the solid experience to teach A-levels, or gifted and talented pupils, or to provide leadership. How can we retain experienced and successful teachers?

There is also the group who have begun their careers, often very successfully, and after less than 10 years 'drop out'. I know of one well-qualified teacher who has done just this. She is a very keen and gifted teacher who attends Mathematical Association branch meetings and is completing a taught master's degree. She is about to give up teaching to go travelling before she 'settles down'.

I have identified three groups of teachers who will be sadly missed. Are there strategies, which could help to maintain their commitment to the teaching of mathematics? How can we retain these well-qualified and experienced mathematics teachers? We need to consider radical strategies. As recently as four years ago paying people to train to be teachers was considered a step too far but now it is pivotal to successful recruitment.

Some strategies.

My premise is that we need to inject excitement into a long teaching career – just as with any long-term relationship! How could this be done?

I believe strongly there are far too few opportunities for mathematics teachers to continue their engagement with mathematics. Secondments, exchanges and release time to explore contexts where mathematics is used could help. Partnerships with professional mathematicians could provide opportunities to keep up to date and to use mathematics. There are funding implications but, just as a number of companies fund and provide mentors for children in schools as part of 'community service' they or others could do the same for teachers. This has attractive outcomes; short-term pay-off in terms of publicity for the company and longer-term pay-off such as a better educated workforce.

Partnerships with university departments could be developed further. Schoolteachers could have the opportunity to learn about and perhaps take part in mathematics research and to teach beyond A-level. The interaction between enthusiastic well-informed schoolteachers and undergraduates could also inspire some of them to take up teaching as a career. It might also raise the status of school teaching in the eyes of some university departments who still see it as a last resort, a low status career for their graduates. Academics could also get involved in teaching in schools! The school students would benefit by being taught by university academics; they would have a fresh slant on a topic, they could gain an insight into undergraduate maths that might inspire more of them to take maths degrees and the academics would gain insights into the current position in schools with A-levels. This would not be terribly costly but would need only the will and some timetabling flexibility on the part of both schools and universities. Once again there could be positive publicity for both partners. Maybe a funded pilot scheme is the way ahead.

The current 'good practice bursaries' available in England for teachers to engage in research into education could be extended to allow teachers to engage in research into a mathematical topic. It may not be practical for this to be research in the strictest sense but might be seen more as 'personal knowledge enhancement'. Similarly I would like to see LEAs and schools support taught masters degree programmes that included modules on mathematics. Currently, most taught masters degrees in education focus on non-subject specific areas such as improving standards, management and special needs. There is now little opportunity for teachers to study the learning and teaching of mathematics let alone to learn any new mathematics. In the modular environment it should be very easy for universities to set up a taught masters that recognises both subject specific credits and 'educational' credits. Once again, cost would be negligible; all that is needed is the will.

Although there are more and more people taking up mathematics teaching after trying other jobs there is still a significant number who will have come the school, university, school route and find themselves approaching 30 without having a wider experience. The desire to travel is strong pull. Can we not devise a strategy that allows for travel and a teaching career to be combined? There have been opportunities within the English speaking world and the Commonwealth for teachers to exchange posts for a term or a year. This could be expanded and go beyond the English speaking world as we now have many multi-lingual young people with the potential to become mathematics teachers. A programme that provided opportunities to exchange posts and teach overseas after say 5 or 7 years experience in the UK might well be attractive. Both of the teachers and their pupils would benefit from the experience. There are cost implications for this but with government support the development potential is good. Charities might be interested in funding particular initiatives.

Finally, I think some teachers just want some space to take a check and reflect and be away from the school scenario. I know how significant my year's secondment to do my masters degree was. Would it be possible to give teachers 3, 6 or 12 months' sabbatical away from school on full salary? There would be significant costs but it could be cheaper than training a new teacher and waiting for them to develop the expertise of a 40-year-old head of department with good A-level results. Maybe a year's sabbatical on full pay after 20 years service would encourage people to stay? This is an ambitious idea, but then we were told they would never pay people to train to be teachers!

If we are to raise standards, particularly for our brightest and best mathematicians then we need experienced teachers, not just NQTs. If the current shortage of good mathematics teachers is to be addressed it is critical that strategies for the retention of mathematics teachers are developed and implemented over the next year.

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Waving or Drowning?

Teaching Adult Numeracy Without a Strong Background in Mathematics

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Abstract

The government's new £1.5 billion *Skills for Life* strategy to improve the basic skills of the 7 million adults deemed to lack them relies on there being sufficient people willing and able to teach 'adult numeracy' at the required levels. However, it has always been difficult to find good adult numeracy tutors and many of those teaching numeracy/mathematics to adults do so without a strong background in mathematics. This paper examines such questions as: What is it like teaching numeracy/mathematics without a strong background in mathematics? What can be done to encourage reluctant would-be adult numeracy teachers to take the plunge? What support do they need to enable them to become sufficiently competent and confident so that they can teach mathematics to others?

Introduction

The shortage of specialist mathematics teachers at Key Stage 3 is mirrored in the post-16/adult sector. Anecdotal evidence from colleagues in colleges this Autumn speaks of desperate searches for anyone prepared to teach numeracy, of people coming forward for classes being turned away because there is no-one to teach them, of numeracy specialist teachers being on a treadmill teaching class after class, and of new staff being taken on with no background or training in adult numeracy teaching, many without a strong grounding in mathematics themselves. The success of the government's new £1.5 billion *Skills for Life* strategy to improve adult basic skills depends on there being sufficient people willing and able to teach 'adult numeracy' at the required levels (equivalent to Entry Level and National Qualifications Framework Levels 1 and 2). However, it has always been difficult to find good adult numeracy tutors and many of those teaching numeracy/mathematics to adults, as at KS3, do so without a strong background in mathematics. As Alison Wolf puts it: 'Because so few sixth formers do A-level maths, there is no pool of mathematicians to draw on as teachers. This creates a vicious circle where people with limited maths end up teaching the subject badly to pupils who might themselves become teachers and be drafted to teach maths' (press release for the publication of Wolf & Tikly, 2000). Others, who might have a lot to offer, have shied away, fearing that they would be out of their depth mathematically.

This paper explores this situation, starting from the conviction that mathematics teachers and researchers in mathematics education in all sectors have much to learn from each other, especially at a time when the school and adult curricula are converging. First some background.

Background

Seven million adults are deemed to lack basic skills. The scale of need for numeracy is even greater than that for literacy, according to research cited in the Moser Report (DfEE, 1999). Recent research by John Bynner and colleagues from the Wider Benefits of Learning Research Centre underlines the implications of basic skills deficiencies for adults. They found that:

> Individuals who improve their basic skills:
>
> - improve their chances in the labour market, moving up the occupational status scale and resisting unemployment;
> - suffer less from poor physical and mental health;
> - are less likely to have children experiencing difficulty at school;
> - are more likely to be active citizens, as shown by voting and expressing interest in politics, and
> - are more liberal and less discriminatory in their attitudes.

After controlling for earlier family circumstances and educational achievement, numeracy was found to be particularly important:

> Level 1 or better numeracy skills produces a return to earnings on average of 26% more than for adults with skills below this level […];
>
> the probability of employment is enhanced by 6% at age 33 (NCDS cohort) if the numeracy target is achieved. (Bynner *et al*, 2001)

The Government has set a target of improving the literacy and numeracy skills of 750,000 adults by 2004. The agenda is ambitious, including:

- free basic education for all adults who want it - to be available by calling a freephone telephone number for details of local courses;
- new measures to improve the basic skills of public sector workers, including the NHS and the Army;
- help for businesses to provide training for their employees with pilots of grants to cover National Insurance for low-skilled workers doing courses;
- a new university based national research centre which will help develop best practice in teaching adults the basics;
- a new national network of up to 2000 fully equipped learning centres at colleges, workplaces and schools, where courses will be provided;
- a new curriculum and standardised tests, with early introduction in nine pathfinder areas;
- improved prison education with a focus on basic skills, and the option that prisoners will have training as one of their licence conditions will be piloted.;
- Jobseekers will have a mixture of rewards and penalties to encourage them to improve their basic skills. (DfEE, 2001)

A raft of measures has been put in place, including a £3.8 million advertising campaign, 'Get On', launched in September and running in the press and on TV throughout the autumn of 2001. The Adult Basic Skills Strategy Unit has been established, run from the DfES but working across other departments and agencies. A new system of inspection, the Adult Learning Inspectorate has been introduced from April 2001, bringing together inspection of adult education and work-based training into a single system. Family literacy and numeracy programmes have been extended from September 2000 to March 2001, with four stands of funding: keeping up with the children; family literacy; family numeracy; family numeracy workshops.

New national standards, curriculum and tests in basic literacy and numeracy have been developed by the Qualification and Curriculum Authority and the Basic Skills Agency (BSA). The new basic skills curriculum is mapped onto the national qualifications framework as follows (indeed, the new Adult Numeracy Core Curriculum draws heavily on the National Numeracy Strategy):

		Key Skills Level 5	National qualifications framework Level 5
		Key Skills Level 4	National qualifications framework Level 4
		Key Skills Level 3	National qualifications framework Level 3
National Curriculum Level 5	Literacy/Numeracy Level 2	Key Skills Level 2	National qualifications framework Level 2
National Curriculum Level 4	Literacy/Numeracy Level 1	Key Skills Level 1	National qualifications framework Level 1
National Curriculum Level 3	Literacy/Numeracy Entry 3		Entry Level
National Curriculum Level 2	Literacy/Numeracy Entry 2		
National Curriculum Level 1	Literacy/Numeracy Entry 1		

(BSA 2000:4)

The curriculum has received a cautious welcome (*viz.* Coben, 2001). But what of the teachers who will teach the new curriculum? In a paragraph outlining the role in relation to ITE and CPD of the Research Centre to be established as part of the strategy, *Skills for Life* states that:

> By identifying best practice and innovative research, the research centre will develop and deliver teacher training and professional development based on quantitative and qualitative evidence of the effectiveness of different approaches to learning, working with and building upon the work of the Basic Skills Agency. Its work will lead to the development of a qualifications structure for teachers of literacy, numeracy and English as an additional language, which will provide a clear career path for those who wish to specialise. And most importantly, its work will enable us continuously to evaluate and to improve our national strategy. (DfES, 2001, para.134)

In other words, there is currently no qualifications structure for adult basic skills teachers, nor is there a clear career path for those who wish to specialise in adult numeracy. Against this background, I shall briefly look at existing research in initial teacher education (ITE) and continuing professional development (CPD) in Adult Numeracy. I shall outline the present situation ITE and CPD in adult basic skills, in order to set the scene for discussion of the questions explored in this paper: What is it like teaching adult numeracy without a strong background in mathematics? What can be done to encourage reluctant would-be mathematics teachers to take the plunge? What support do they need to enable them to become sufficiently competent, confident and comfortable with mathematics so that they can teach it to others?

Initial teacher education and continuing professional development in adult basic skills

There is at present too little ITE and CPD in adult basic skills and what there is is fragmented, with no overall framework connecting the various elements. There are gaps in provision, with a shortage of pre-service courses, patchy availability of courses at all levels and no consistency in quality or extent of provision for literacy, numeracy and ESOL; numeracy is particularly badly-served. At PGCE level (H2/3) and beyond (e.g., postgraduate Certificate, Diploma and Masters and doctoral studies) there is very little specialist provision, although basic skills teachers can – and some do – focus on their field in generic post-16/adult PGCEs and in postgraduate studies and research. A few have studied and/or researched adult basic skills at postgraduate level but the British Society for Research into the Learning of Mathematics Directory of PhD Theses in Mathematics Education currently has no entries under 'Adult Learning'. Some practitioners are teaching without benefit of training and until now there has been no such thing as qualified teacher status for working in the extremely diverse adult/post-16 sector. Recruitment is also a problem: there is a shortage of basic skills teachers; adult basic skills teachers from ethnic minority groups and adult numeracy teachers from any background are in particularly short supply.

The new qualifications framework for teachers in further education (FE) in England which is being introduced from September 2001 by FENTO, together with the launching of the *Skills for Life* strategy, offers the chance of substantial change. The key features of the FENTO qualifications framework are as follows:

- all new entrants to work towards a nationally-recognised qualification;
- existing unqualified staff to achieve qualification through CPD;
- qualifications will comprise 3 stages: stage 1, 2 and 3, with stage 3 being a Certificate in Education or equivalent;
- all 3 stages are at the same academic level - national qualification framework (NQF) level 4, or H1. The difference between the stages is in the breadth of coverage;
- all teacher-training qualifications are to be based on the FENTO standards for teaching and supporting learning;
- FENTO to endorse all qualifications in order for them to be nationally-recognised (courses in HE need to conform to QAA guidelines;
- qualifications can be developed by awarding bodies (ABs) and Higher Education Institutions (HEIs).

Under this framework, qualified FE teachers will have demonstrated capability in the following 4 components:

Component 1 - Generic teaching;

Component 2 - Teaching in context;

Component 3 - Subject competence*;

Component 4 - teaching the specific subject/occupational area.

> *Subject competence in literacy and numeracy will be demonstrated by meeting FENTO Standards for Literacy and Numeracy at NQF levels 3 and 4. The Draft Standards are currently being revised following consultation.

As indicated in *Skills for Life*, from September 2001, FE teachers of all subjects will be working towards a teaching qualification that includes literacy and numeracy among its key elements. Also from September 2001, all teachers employed to teach basic skills in FE will be required to hold, or work towards and achieve in a specified time, a specialist basic skills teaching qualification.

The FENTO update of September 2001 states that in order to be nationally-recognised, all FE teacher-training qualifications in England are to be based on the FENTO standards for teaching and supporting learning from September 2001. The academic level of the teacher training qualifications is to be a minimum of level 4 on the national qualifications framework/level H1 for HEIs. In addition, with respect to specialist literacy or numeracy teaching:

Specialist literacy or numeracy teachers are subject to the same qualification requirements as all FE teachers. However, FENTO has developed subject specifications for literacy and numeracy at levels 3 and 4 which can be used for the following:

> specialist qualifications for unqualified staff. The level 3 subject specifications for literacy and numeracy will be underpinned by the FENTO standards for teaching and supporting learning to develop specialist qualifications;
>
> continuing professional development (CPD)/progression qualification. The level 4 subject specifications will be used to develop higher level qualifications/CPD units for specialist staff;
>
> standalone qualifications. These literacy and numeracy qualifications, based on the level 3 and 4 subject specifications, can be used by teachers who already possess a teaching qualification but wish to achieve qualifications in literacy and/or numeracy. (FENTO 2001)

The FENTO changes coincide with the introduction of the new Adult Numeracy Core Curriculum and its sister curriculum in Adult Literacy. The new curricula have associated tutor training, through which the Government plans that all teacher trainers will have received five days training by the end of 2001; all existing teachers should have received three day training by summer 2001. A tool-kit and training programme is being piloted. The Basic Skills Agency and FENTO are developing a new initial teacher training framework and qualification for new entrants to basic skills teaching.

But who are these teachers and what is their background? At the moment we do not know very much about who teaches adult numeracy - where, when and to whom, and what qualifications they hold. These are issues that the new National Research Centre planned for January/February 2002 may address. The Basic Skills Agency is currently asking all delegates who attend training on the new curriculum to complete a questionnaire which requests information on their background, qualifications, and teaching position. By the end of October BSA should have returns for approximately six thousand teachers. However, only tutors who currently teach six or more hours per week are eligible for the training, so the data will only apply provide information on teachers who have met this criterion. In the absence of fuller information, I shall briefly outline what is clear from existing research on ITE and CPD in adult numeracy.

Existing research on ITE and CPD in adult numeracy

Adult numeracy is seriously under-researched and, in terms of both provision and research activity, has been the 'poor relation' of adult literacy in England since the 1970s (Coben, O'Donoghue & FitzSimons, eds, 2000). Research in ITE and CPD for adult numeracy education is similarly a neglected area, although this is changing fast, in part through the work of practitioner researcher networks such as Adults Learning Mathematics – A Research Forum and ANN, the US Adult Numeracy Network. However, there is still a shortage of experienced adult numeracy researchers, to match the shortage of teachers. There is, of course, relevant research on teacher education in relation to children's learning of numeracy. A good example is Margaret Brown and colleagues' examination of the relationship between teachers' qualifications, CPD experiences, beliefs, and classroom practice and their pupils' learning, using observation of practice in classrooms and CPD courses, and assessment of pupil gains in national numeracy tests. They found (Askew et al., 1997) that CPD experiences, beliefs and practices were related to gains in these tests. There is also a body of research on teacher education for teaching adults, but very little of it relates to teaching adults what is variously known as 'basic mathematics', 'everyday mathematics', 'numeracy' or, in the USA, 'quantitative literacy'. Work on ITE and CPD for adult basic skills generally tends to have a literacy, rather than a numeracy focus: nevertheless, there are lessons to learned from it. For example, Alan Rogers' work in developing countries (Rogers 2001) points to the need to integrate what we know about good adult teaching and learning methods generally into adult basic skills teaching and to base teaching – and, by implication, teacher education - in adults' contexts and purposes for learning.

Possible models for research and development in adult basic skills ITE and CPD exist in North America, where the US National Centre for the Study of Adult Learning and Literacy (NCSALL) and NALD (National Adult Literacy Database), Canada's adult literacy information network, are doing relevant work. Similarly, in Australia, ARIS the Adult Education Resource and Information Service, has a strong adult numeracy education strand. Interesting ITT/CPD materials have been produced, including the *NCSALL Study Circle Guide: Performance Accountability in Adult Basic Education* (NCSALL 2000) and, in Australia, ANT, an 84 hour numeracy tutor training pack, entitled, *Adult Numeracy Teaching - Making Meaning in Mathematics* (discussed in Coben & Chanda 2000). ANT weaves together three strands: 'knowing about maths; learning (and teaching) maths; and doing maths' The authors are unequivocal about a point central my argument here: 'This last strand is central to the course: clearly to teach numeracy you must know how to do mathematics' (ANT, quoted in Coben & Chanda, 2000).

As has generally been the case with adult numeracy, research has yet to catch up with practice. However, with all this activity in ITT and CPD and the introduction of the new curriculum, avoiding numeracy will no longer be an option for trainee FE teachers, who will have to meet the FENTO Standards for literacy and numeracy. Adult numeracy teachers are already benefiting from the training to support the introduction of the new curriculum and the prospects are good for further development through the National Research Centre. But how many will take up the new opportunities? Will the crisis in recruitment of mathematics teachers at KS3 be replicated in adult numeracy? If it is, this will not be a new phenomenon. Joy Joseph (1997) researched the take-up of tutor training in adult numeracy in the mid-1990s, using reports from the Adult Literacy and Basic Skills Agency and its successor, the Basic Skills Agency, for 1993/94 and 1994/95 and information from City and Guilds. She found that take up was markedly less for numeracy than for literacy amongst paid staff, though interestingly this was not the case amongst volunteers.

Some of those who take up the challenge of adult numeracy teaching may not have a strong background in mathematics, a point confirmed in conversations with FE colleagues, as already stated. In the next section I shall consider what it is like teaching numeracy without a strong background in mathematics, before looking at what can be done to encourage reluctant would-be mathematics teachers to take the plunge, and to support them once they have done so.

Teaching adult numeracy without a strong background in mathematics

From my own experience as an erstwhile adult literacy and numeracy tutor, I know that it can be challenging teaching adult numeracy without a strong grounding in mathematics. I became involved in numeracy work in response to students' requests for help with their mathematics, rather than from a background in mathematics or mathematics teaching. When I look back on my years of teaching adult numeracy, I do not remember feeling out of my depth mathematically, even when one of my students asked for help with the mathematics he needed to support his hobby – astronomy, an area in which my knowledge base was decidedly thin. I do remember concentrating hard so as not to glaze over when another student, realising I had never set foot in a betting shop, explained the intricacies of betting to me. But that was because I was not interested in gambling, rather than because I could not follow his arithmetic. Reflecting on that incident, I resolved always to work through the student's interests. If I got stuck, I would try any or all of the following: go back to first principles; try a variety of approaches to see what worked; use a calculator or other aid; simplify the problem as far as possible, breaking it into stages, and substituting awkward numbers for 'easy' ones; discuss what I was trying to do with other people; look up the answer if there was one in the back of the book, and work back from there. All these techniques and more I taught to my students, who seemed, on the whole, to thrive. When I was asked, as I often was – and still am – (but never by adult numeracy students) 'Have you got a maths background?' I would say 'No, I have a maths foreground'. It has stood me in good stead. Nevertheless, I know from my work as an adult numeracy tutor trainer that not everyone is prepared to have a go as I did. Teaching too near the limit of one's competence is hardly desirable for teacher or student, and can be very nerve-wracking, especially for the novice teacher. So what can be done to encourage reluctant would-be adult numeracy teachers without a strong mathematics background – or foreground - to take the plunge? And what support do they need with their mathematics to enable them to teach others?

Perhaps the second question is the answer to the first. If support were available, in the form of substantial ITE and CPD, mentoring schemes, helplines, email lists and chat rooms, perhaps more people would feel sufficiently confident to come forward. Whether face-to-face or in cyberspace, adult numeracy teachers without a strong mathematics background need the opportunity to come together with other teachers in an unthreatening environment where they can learn the mathematics they feel least comfortable with and recognise and celebrate what they already know. I feel particularly strongly about the latter point. In my research with Gillian Thumpston on adults' mathematics life histories (Coben & Thumpston, 1996) we found that adults often disregarded the mathematics they could do, dismissing it as 'just common sense'. Mathematics was what they could *not* do, so it was always out of reach. In my adult numeracy teaching, I tried to find ways of building on people's 'common sense', helping them to recognise that they could do more than they gave themselves credit for; the same goes for tutor training when the trainee feels out of her depth.

Some final thoughts

The issue of subject knowledge and subject competence for teaching numeracy is extremely complex, not least because there is no consensus as to what numeracy is (Evans, 1989). Adult numeracy teachers have been inadequately served in the current pattern of ITT and CPD; it remains to be seen what will emerge from the FENTO consultation. Teachers clearly need to be competent in the skills they are teaching, but they also need to develop awareness of mathematical issues likely to impact on their students' learning, so that they can understand their students' strengths and weaknesses and plan their learning programmes accordingly. For example, a numeracy teacher needs not only to be able to do mathematics, as the authors of ANT insist (although to what level is an interesting question), but also to understand and analyse problems that a student may have in doing mathematics.

Much remains to be done, and the work of the FRAME Teaching Development Group (2001) is pointing the way in its work in formulating a research agenda for mathematics education at all levels. Recently, with two colleagues from King's College London, Alison Tomlin and Dhamma Colwell, I agreed on the following draft list of attributes and abilities that adult numeracy teachers need (not in any order of priority):

> an understanding of the influence of cultural factors and language on approaches to mathematics;
>
> recognition of the different ways in which mathematical understanding can be expressed, including cultural differences in the ways calculations are made;
>
> an understanding of the appropriate degree of accuracy required in solving different kinds of problems;
>
> the ability to describe their own thought processes in solving a problem;
>
> awareness of different methods for solving a problem – the ability to rethink concepts in order to represent them in different ways (e.g., multiplication as repeated addition, etc.);
>
> awareness of differences in individuals' uses of methods and an ability to understand and respect learners' methods;
>
> awareness of the appropriateness of different strategies in different contexts;
>
> awareness of the language used to formulate problems, consider them, solve them and formulate an answer;
>
> to be able to investigate a mathematical topic and formulate general statements about it;
>
> to have an understanding of the way in which different mathematical topics relate to each other, e.g., fractions, decimal, percentages, algebra and co-ordinate geometry;
>
> to be able to be critical about the gathering of statistical information and its presentation;
>
> reflectivity about one's own learning process;
>
> knowledge of ICT (calculators, graphical calculators, spreadsheets);
>
> awareness of the relationship between 'standard' mathematics and everyday uses of mathematical vocabulary;
>
> knowledge of mental calculation strategies.

It is a daunting list. It may be the beginning of an agenda for ITT and CPD for adult numeracy. The initiative of the Centre for Mathematics Education at the Open University in convening this conference is a welcome opportunity to learn from each other across educational sectors about attempts to meet the staff development needs of those teaching without a strong background in mathematics. My thanks to participants at the 'Teachers as Learners' session, to which this paper was a contribution, for their comments and suggestions, outlined below (I hope, accurately):

> adult numeracy teachers could re-work National Numeracy Strategy materials, as a training exercise, for use with adult students;
>
> all teachers need to develop a different attitude towards teaching and learning in parallel with their students, so that they see themselves as co-constructors of knowledge – training can help here;
>
> teachers need to be trained to recognise and teach the linkages between, e.g., fractions, decimals, percentages, ratio and proportion;
>
> adults' work role should not be seen as their key or sole identifying role;
>
> family numeracy initiatives seem to have been successful in reaching adults keen to improve their own, as well as their children's numeracy; teachers need to recognise this;
>
> oral-mental strategies for manipulating numbers taught at KS1 and KS2 could be very relevant to adult learners and teachers;
>
> recruitment, retention and success are all important for teachers and ITE/CPD has a valuable role to play in all three;
>
> CPD needs to be based on an acceptance that teachers may pick up, drop out of and come back to training throughout their careers – more split courses would be helpful;
>
> the Adult Process Classroom (APC) approach, in which teachers pose a problem in an adult context, then move to the mathematics and how students feel about it, could be taught to trainee adult numeracy teachers.

It is to be hoped that exchanges of ideas such as this, backed by government commitment in the form of the *Skills for Life* strategy, and, in particular, the new National Research Centre, may help to address the needs of adult numeracy teachers for staff development that leaves them waving, not drowning, in their teaching careers.

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Teachers as Learners:

Teacher Education in Mathematics and Science in a Professional Context

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Abstract

The threatened shortage of teachers in Sweden, in particular in mathematics and science, has forced the Swedish government to make special efforts to attract students from other areas of working life to teacher training. One initiative is a project designed both to attract untrained teachers to finish their degrees and also to support teachers in other subjects gaining an education in mathematics and/or science. This nation-wide project has now finished its first two years and is being extended for a new period. This paper describes the project and examines it as a co-operative venture between organisations with a starting points and goals which can be interpreted at individual, at systematic and at socio-cultural levels.

Background

In Sweden, the number of teachers in the primary and secondary school system is approximately 24 000. The prevailing shortage of teachers is projected to worsen, due to forthcoming retirements and an increase in the school-age population; and the number of trainee teachers is already considered to be far too low. In times of shortage, those who have a degree, but have not yet finished their teacher training, may be employed as full teachers. According to the most recent reports from the National Agency for Education in Sweden, approximately 20% of the teachers in the Swedish school system lack a degree from a Teacher Training Programme.

This is the overall shortage of trained teachers, but the problem is even worse with teachers of mathematics and science. Not only are current and future shortages more pronounced but the number of untrained teachers is even higher. Moreover, only 70% of the student teachers in mathematics and science finish their training and receive a degree (Reuterberg, Svensson & Berndtsson, 2000). This complicates the picture even more, since the preliminary estimate of the forthcoming shortage is based on the number of teacher students accepted for training and not on estimated graduation.

Explicit aims for the new nation-wide programme of teacher training which started this term are: to increase the number of students in mathematics and science to 30%;

to increase the number of male students; and to increase the number of students with a foreign background. There is also a strong commitment to enabling adults who are interested in going into teaching to build on previous professional training and, with a shorter programme, to gain a teaching degree.

This paper reports on a joint project to attract untrained teachers to train in education and to finish their degrees, and to support teachers of other subjects to qualify in mathematics and/or science. Several organisations, as well as universities and colleges, took part in the venture and the results of the project will be described and related to individual, systematic and socio-cultural aspects.

From a methodological point of view this project might best be described as an instance of action research (McNiff, 1991). Although most examples of action research projects concern schoolteachers investigating their own practice, we are university teachers investigating *our* practice. Our aim has been to implement the project as well as to describe and theoretically analyse the project: its purpose, its process, and its outcome. Here we give a brief description of the progress and outcomes of the project, and conclude with reflections on the project from a theoretical standpoint.

A special teacher training programme

The Ministry of Education, The National Agency for Education, The Swedish Association of Local Authorities, and the Swedish Teachers' Unions, agreed to support the project and the commission was given to four different universities and colleges to run the project for two years (1999-2001). The National Agency for Higher Education was to evaluate the project. The programme was planned as a distance programme with complementary courses at the four institutions.

The programme would accept 200 students of which 80% would be mathematics and science graduates. Each student would either become a qualified teacher for primary or secondary school by completing his/her PGCE, or study mathematics or science if they had a degree in another subject area. Normally, a complete programme for these degrees lasts for four-and-a-half to five years in Sweden. This project. would involve not more than two years of half-time study for the student to gain a degree (i.e. the equivalent of 30 credit points (EU) or 120 credit points (UK)). Other criteria were that students should be employed as a teacher at least part-time, and should receive support from their local council. As the students taking part in the programme had different needs and any student could study at different universities and colleges, individual plans were drawn up for each student. These took account not only of the formal requirements for each course but also of the students' real competencies.

The support from the local council involved appointing a school mentor for the trainee, reducing the teaching load, and providing expenses for books and travel. However, the level of support varied not only between councils but also within councils, with students from the same area being treated differently.

In total, 540 teachers applied for courses, and 268 were accepted. However, as many as 57 students had to withdraw: they could not cope with the course due to a very low level of support from their school. Thus, 211 students undertook the programme during the two years. Approximately 50% of them studied for their PGCE and almost as many took separate courses in maths and science.

This project was a first step towards a nation-wide programme of distance education for teacher training. Some of the units of study were already running as part of the distance education programme at each university/college, while others had to be newly devised. An example of the latter was the course in mathematics at Malmö College. With the same standard and content as the regular course in mathematics for teachers, this course was partly, but not fully, web-based. All courses, however, were computer aided to a greater or lesser degree, having a conference system or a message-board. These aspects were complemented by sessions at the institution for either two or three consecutive days or for a whole week.

The students

Once the students had enrolled we looked to see whether the criteria for the student intake of the project were being fulfilled. 49.8% of the students were female while 50.2% were male, so the aim to recruit more men was certainly fulfilled. The students with a foreign background were 11.8%.

The goal of accepting 80% of students in mathematics and science, was more difficult to reach. Such students comprised 74.4 % of the intake with 14.7 % in modern languages, 2.8 % in vocational teacher training and 8.1 % in various other subjects including history, religion, social sciences and arts and handicraft.

A third aim of the project was to accept students with backgrounds in other professions and with work experience outside the school system. Only 32% of the trainees were in the age group 20 to 29 years, while 30% were aged between 30 and 39, and 29% between 40 and 49; 7% were more than 50 years old. This meant that two thirds of the students had experience of working life outside school.

These students were professionally experienced and were working as teachers. They were a heterogeneous group of varied backgrounds, ages, interests and subjects. Of course this made the atmosphere in the seminar room different from that of the regular teacher training courses. The students were made to reflect on issues of learning, teaching and education and were introduced to critical thought, to a more scholarly attitude and to reflective practice. The academic teachers found these students more demanding and more motivated, but also more difficult to teach.

Discussion

Co-operation as a way of solving problems on a national level.

Hargreaves (1994) asserts that co-operation is a more efficient way of solving problems and a guarantee of higher quality. It has implications for learning, and for continuous evaluation and development.

In the project described here, the individual study plans devised for each student were discussed with the student, the university and the local authority. Such co-operation between different organisations, between the HE institutions and the Swedish government, the Swedish Association of Local Authorities and more than 70 local councils, has proved that it is possible to put rivalry and conflicting interests aside. If we are going to solve the problem of teacher shortage, especially in mathematics and science, we cannot compete with each other – co-operation is the only way.

Other examples of co-operation in Sweden are the 'Attractive School' project where 34 school districts take part in a network to raise school quality; and the recently suggested Swedish Net University where students at the national level will be able to get a degree from courses at different universities and colleges.

Consequences on the individual and the systemic as well as the socio-cultural level.

An evaluation of the outcomes of an action research project needs to consider not only the goals and aims of the project: it is also necessary to look at the consequences on a more general level. In Andersen *et al* (1996) a model is described which outlines the different spheres affected by developments in working life.

For individual students, this project has made a difference on the personal as well as on the professional level. The support from the local council has shown that the trainee teacher is important to the school and to the local society: it acknowledges the importance for the council of having trained teachers in schools on a long-term basis. In the past, these teachers have often not been accepted as part of the staff although some of them have worked at the same school for a decade or more. Although they know their subjects well – for instance, some have doctorates in modern languages – they have not had the opportunity to reflect on the teaching of their subjects before embarking on this course. The students find that having a mentor at school means that they have someone to turn to with their thoughts about teaching.

For the school, having one or two of their teachers in training means that tasks and assignments have to be carried out and solved in practice. Some schools have experienced a rise in quality as changes have to be pedagogically based and related to theory as well as practice. Having a trainee teacher is an asset for the school, as well as the school district. One of the students who wrote a paper on grading examinations was headhunted by the local examination committee while collecting data for his paper. The co-operation inherent in the project also means that the university or college providing the teacher training is in touch with the school and the council.

For society at large, high-quality teachers at higher-quality schools means a better future for children. The three criteria of the project – more men, more teachers with a foreign background and more teachers in mathematics and science – all have future implications for society.

Currently, only 20% of the teachers are men. With teaching being badly paid, men tend to avoid or leave the profession. Boys and girls need more men at school, since the largely single-gendered teaching profession gives a false picture to children, as if only women care about children sufficiently to accept the low pay. As many families are single parent, often single mother, this reinforces the need for more male teachers.

Teachers should reflect the multi-ethnic picture of the area and society at large. In particular, school districts in the cities need to employ more teachers with a background similar to that of their children. Many immigrants with previous school teaching or teacher training experience in other countries work as teachers in the cities today; the aim of this project was to give them a degree. Some of these trainees said that the training gave them an insight into the Swedish school system and enabled them to befriend Swedish trainees, neither of which would have happened otherwise.

The untrained teachers are to a large extent teachers in mathematics and science. Professional people with a background in engineering, industry, manufacturing and trade have decided or been asked to come into school and teach what they have learnt in their vocational training and in their university education. Although they might have previously taught at university or evening schools, they now wish to teach in schools. The aim of the project was to graduate 160 new teachers in mathematics and science: this was not quite achieved, but the results were very close.

Teacher training in mathematics and science as the merging of two cultures.

Why do we have to use extraordinary methods like a special teacher-training programme in attracting teachers to mathematics and science? In order to understand this we have to turn to Habermas' theory of communicative action (1991). This theory tries to capture the discrepancy between the systemic level of action and the life-world of the individual. We cannot understand social action unless both levels are accounted for. The shortage of teachers in the post-modern era has explanations at a systemic level as well as an individual one.

Svein Sjoeberg (2001) claims that young people are heavily influenced by media in their choice of career and are not attracted by science. A popular stereotype in post-modern media sees scientists as nerds, madmen, or evil. The image of a teacher of science is old-fashioned and post-war rather than reflecting the 21st century. In Habermas' terms resistance to becoming a science and maths teacher is also a form of resistance to the social system as young people apprehend it. There is a paradox in teaching maths and science: teaching is an expression of a humanistic paradigm and doing mathematics and science an expression of a more instrumental paradigm. The shortage of teachers in this area could imply that there is a clash in paradigms. For young people, teaching means following a humanistic and social way of life, while going into science means going into private enterprise, engineering, research and problem solving in a world which is apart from children and students.

However, if we turn to the issue of life-long learning and career change, some professionals in industry, engineering, manufacturing and business will turn to teaching as a form of resistance to what they think of as the social system. This is where the project we have described above fits in.

Teacher training in the future

New reforms have now superseded this project. For the first time, the new programme for teacher training enables primary teachers to go back to university or college and, with additional education, receive a degree for secondary school teaching in mathematics and science. With one degree for all teachers at all stages there will be more possibilities to switch from other professions to teaching.

The project described here has been extended. In the preliminary government plans for the next six years, 4,000 more teachers are to be trained in this way. In the years 2002-2004 students will be recruited for distance-learning courses which will be half-time for three years. All students will either gain a degree or, if they already have one, study another subject. It is hoped that between 60% and 70% of these will be in mathematics and science.

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Rebuilding the Profession of Mathematics Teaching: Where are we and where can we go?

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Introduction

There is a need to raise the status of the teaching profession in general. The General Teaching Council holds that

> Teachers as professionals should be trusted to exercise individual judgement that draws on their knowledge, experience, integrity, commitment to students and specialist training.

It is important to consider what this means for teachers of mathematics. In order to exercise such judgement appropriately, teachers of mathematics need sound knowledge and understanding of the content of the mathematics curriculum, and an understanding of how to sequence the content effectively for learning. They also need to be clear about the goals of mathematics education.

All students must be 'mathematically proficient'

In the U.S.A., as in the UK, there is concern about the shaky grasp of mathematics held by many elementary (primary) and middle-school teachers. The National Research Council of National Academies has recently issued a commissioned report on the teaching of mathematics in the U.S.A. called *Adding it up: Helping Children Learn Mathematics*.

The committee which produced the report included members with expertise in research in mathematics education, mathematical sciences, research in cognitive psychology, classroom practice, and business. The report is based on a review of existing research in mathematics education and concludes that all students must be 'mathematically proficient'.

What is mathematical proficiency?

As conceived in the report, mathematical proficiency is much more than disconnected facts and procedures. It has five intertwined and equally important strands, namely that mathematically proficient students should be able to:

understand & apply important concepts
compute with ease
formulate & solve problems
explain their reasoning
have confidence in their abilities, and view mathematics as a sensible and worthwhile subject

In order to facilitate the development of mathematical proficiency in all students, teachers should teach important concepts in depth, instead of being asked to cover a multitude of topics superficially. Significant time should be devoted to daily mathematics instruction in every grade of elementary and middle school. Exams should test students' progress in all five strands of mathematical proficiency.

What does it take to teach for mathematical proficiency?

The report found that teachers were often unable to clarify key concepts for learners or to solve problems that involve basic calculations. In order to be able to teach for mathematical proficiency, teachers of mathematics need mathematical knowledge of their own, knowledge of their students and knowledge of instructional practices.

Necessary mathematical knowledge includes knowledge of the goals for teaching mathematics – hence teachers need opportunities to *unpack* and explore their own knowledge of mathematics. Teachers also need knowledge of their own students and of the ways in which they learn. Their knowledge of instructional practice needs to include curriculum, tasks, tools and how to *design* and *manage* classroom discourse.

In order to achieve these professional goals, teachers should have more time and resources to

acquire solid understanding of mathematics
improve their techniques

This means mathematics teachers need continuous and high-quality training and useful instructional materials. Teachers with special training in maths should be available in all elementary schools to assist colleagues.

> One thing is to study whom you are teaching, the other thing is to study the knowledge you are teaching. If you can interweave the two things together nicely, you will succeed... Believe me, it seems to be simple when I talk about it but when you really do it, it is very complicated, subtle, and takes a lot of time. It is easy to be an elementary school teacher, but it is difficult to be a good elementary school teacher.
>
> Quoted in Ma, 1999, p.136

This U.S. report can inform thinking on how to improve mathematics teaching in this country.

Radical solutions are needed to keep the teachers we have

We need to treat mathematics teachers as professionals. This has far-reaching implications. Teachers should be expected to be supported in designing and planning over time their *own* professional development and expect it to happen. Teachers should be actively supported in continuing study and research. They should be provided with taught masters programmes or PhDs in mathematics or mathematics education or other *extended* continuing professional development.

Teachers should expect changing perspectives on professional knowledge. There should be an appropriate balance between security and familiarity on the one hand and surprise and change on the other. The integration of ICT into teaching strategies is an example of the need for the latter.

Teachers should expect that sabbaticals, secondments, release time, exchanges and travel form an integral part of their professional development. In return, they should expect to contribute to all aspects of the teaching profession, becoming involved, for example in partnerships with HE and industry and with collaborative design and evaluation of teaching and teacher education.

Radical solutions are needed to recruit new teachers

In the light of current shortages of teachers of mathematics, we need short, medium and long-term solutions. We need to further develop strategies in both school and HE. We need also to encourage teaching as a second career (after proper retraining).

We might learn from other countries such as France where there is over-supply of maths teachers. In France there is relatively high unemployment which inevitably helps teacher supply, but in addition teachers are given high professional status as civil servants. They have a two year teacher education programme and they have teaching assistants.

We need also celebrate and exemplify the need for mathematical proficiency *for all*.

Maths is needed in the workplace

The Science, Technology and Mathematics Council in conjunction with the English Regional Development Agencies has funded a project *Maths Skills in the Workplace* (May 2001 - March 2002) which is based at the Institute of Education. The project aims to identify employer needs and expectations in respect of the mathematical skills required to operate and run their businesses.

The project has identified many examples of the application of mathematical proficiency at work. These include:

modelling with quantitative variables
predicting, interpreting trends and debugging
team work and swapping between multiple representations
using initiative with judgement.

Joint Mathematical Council initiatives

Two recent initiatives of the Joint Mathematical Council are relevant to this conference:

An enquiry commissioned by The Royal Society into the teaching of geometry in schools and colleges. The report is now available.

The setting up of an Advisory Committee for Mathematics Education (ACME), which will provide a forum for discussion with government about issues related to mathematics and mathematics education.

Summary

In conclusion, we, together with curriculum planners and policy makers, should recognise:

the importance of teacher education and teacher educators

the importance of teachers engaging in maths for themselves as well as for teaching, to learn as well as to teach

that maths is complex (tool and object, structure and language) and maths teaching is also complex

that the maths we teach *must* change and this is good!

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